SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2025
ORGANIZATION AND MANAGEMENT SERIES NO. 218

OUTLOOK FOR THE DEVELOPMENT OF MODULAR CONSTRUCTION IN POLAND – A CASE STUDY

Łukasz GRUZ[1*], Tomasz NOWAKOWSKI[2], Leszek MIESZKALSKI[3],
Izabela WIELEWSKA[4], Julia MACIOCHA[5]

[1] Warsaw University of Life Sciences; lukasz_gruz@sggw.edu.pl, ORCID: 0000-0001-8008-1899
[2] Warsaw University of Life Sciences; tomasz_nowakowski@sggw.edu.pl, ORCID: 0000-0003-2376-4284
[3] Warsaw University of Life Sciences; leszek_mieszkalski@sggw.edu.pl, ORCID: 0000-0001-5533-7370
[4] Warsaw University of Life Sciences; julia_maciocha@sggw.edu.pl, ORCID: 0000-0002-8045-0794
[5] Bydgoszcz University of Science and Technology; wielewska@pbs.edu.pl, ORCID: 0000-0002-1721-6890
* Corresponding author

Purpose: The paper analyses the residential construction sector in Poland, with a particular focus on single-family housing in Poland regarding the modular and prefabricated house market. The analysis covered the share of the modular and prefabricated house market, construction costs, prefabricate production processes, construction site work, production waste management issues.

Design/methodology/approach: The subject of observation and evaluation of the cost level were industry reports, technology block diagrams and price calculations using information provided by the business entity under review. The presentation and detailed analysis of the available data took the form of tables and bar charts, supported with descriptive explanations. The source of information for this study was literature on the subject, statistical data and numerous studies by the Statistics Poland (GUS) and Eurostat, reports in the industry section, an interview with the owner of a construction company, analysis of financial documents provided by the business entity examined, as well as the authors' own observations. The company's characteristics, revenues, costs and sales market were examined. In addition, the machinery and production technology of the examined company were analysed.

Findings: The case study is a plant producing houses using prefabricated modules, on whose example the production process of prefabricates and their use in the construction of a residential building was analysed. Examination of the production process enabled detection of the problem of production waste management. The paper presents an overview of the characteristics of the production facility with particular focus on the technological processes. Issues related to the cost of building prefabricated houses were also analysed.

Research limitations/implications: The analysis is limited to statistical data and to data provided by one prefabricated house production facility.

Keywords: cost, production, modular houses, prefabricated houses, wood waste.

Category of the paper: research paper.

1. Introduction

Building a house is an important stage in a person's life (Yifei et al., 2023). Many people feel the need for more privacy, which is not offered by living in a multi-family building, and therefore choose to build a detached house (Lihtmaa et al., 2024; Daly et al., 2025). This results in a continuously increasing number of newly constructed dwellings of this type being put into use (Douhard et al., 2024; Ziari et al., 2025). The number of detached houses constructed in Poland is increasing year by year (Trojanek et al., 2023; Karpinska et al., 2020). In 2014, 69260 single-family buildings were completed, followed by 106261 in 2021, 109308 in 2022 and 96170 single-family buildings in 2023 (GUS, 2020, 2021, 2022, 2023). The number of new buildings put into use has regularly increased over these years despite the COVID-19 pandemic, skyrocketing prices of building plots, building materials and building services (Rynekpierwotny.pl, 2024). Ensuring energy security for new construction projects not only at the in-use stage, but also at the construction stage, is vital. Modern energy systems are used for this purpose (Mikielewicz et al., 2019; Kosowski et al., 2009; Tucki et al., 2020; Kosowski et al., 2019).

Building a house using the conventional technology is very energy- and material-intensive, which undoubtedly affects the investment costs and the environment (Chardon et al., 2016; Tucki et al., 2021). The energy needed to build a house and the energy used to produce building materials emits harmful substances into the atmosphere (Xiaocun et al., 2021; Bansal et al., 2014). The use of raw materials to produce building materials is increasingly exploiting the Earth's natural resources (López-Sosa et al., 2025; Ghafoor et al., 2024). They are manufactured using non-renewable energy sources, which contributes to the depletion of the Earth's resources. In addition, the issue of exhaust emissions must be taken into account (Tucki et al., 2019; Tucki et al., 2029). One should emphasise that building a house is an expensive endeavour (Kb.pl, 2025; Rynekpierwotny.pl, 2024). The demand for traditional building materials is very high, which translates into high and still rising prices. In the case of single-family houses built in the traditional technology, the average cost of building a single-family house in 2025 for a 100 sqm builder’s finish single-storey house is PLN 429,000 net (an increase of 3.13% compared to 2024). In the case of a 140 sqm house, the average construction cost in January 2025 was PLN 551,000 net (an increase of 5.57% compared to 2024). In the case of a 200 sqm house, the average construction cost in January 2025 was PLN 619,000 net (an increase of 5.99% compared to 2024) (kb.pl, 2025).

An alternative to building houses using the conventional construction technology is the production of prefabricated or modular houses (Su et al., 2024; Chen et al., 2024).

When talking about prefabricated houses, people often confuse them with modular homes (Tavares et al., 2019; Al-Sammar et al., 2024). Both techniques use prefabricated components, but they represent two different trends in the building industry. Prefabricated construction is based on the erection of buildings using prefabricated components of various designs. Prefabricated elements do not form modules that the entire building is divided into, but are, for example, ready-made wall or ceiling elements. This technique is more of a competitor to traditional construction, as most of the work is done at the construction site anyway and the building is permanently connected to the ground.

Prefabricated houses arrive in the form of walls and ceilings, and once installed, the entire connection and finishing process is left to the investor. Modular houses are delivered as finished interiors and, after assembly, only the connection points need to be closed and the building is ready for use. The assembly time at the construction site is usually a few days for both technologies. However, the difference is in the finishing of the building – in prefabricated construction, the entire finishing stage takes place at the construction site and takes much longer.

Prefabricated houses are made of ready-made wooden structures. They are produced in a production hall under controlled conditions over a period of approximately 12 days. Finished prefabricated elements are transported to the construction site, where they are assembled on a previously prepared foundation slab. This significantly reduces the construction time of a house, as the work to create the building shell at the construction site takes about 2-3 days. In contrast, the building shell in the brick construction technology can be completed no earlier than within 2 months.

Modular houses are made of prefabricated elements that are connected together in the factory to form entire building sections, which are then transported and assembled at their final location. Modular houses are also largely made of prefabricated elements, but they are characterised by repeatability of the basic modular unit. The main idea at the design stage is to use modules of similar dimensions. They may differ in terms of details or functions, but they ultimately form one building. This allows for a significant reduction in the time needed for planning and execution. The modules are designed for transport and can be almost completely finished at the factory (including installations and interior finishing). Unlike a prefabricated house, modular houses do not have to be permanently attached to the ground, so it is possible to dismantle the modular building and transport it to another location. Finished modules are usually transported to their destination on a truck trailer, which means that their dimensions (especially the width and height) depend on the size of the vehicles that transport them.

The most commonly used solutions in modular construction are undoubtedly steel containers and wooden frame structures. Prefabricated elements made of expanded clay concrete, reinforced concrete elements, reinforced PVC or cement-bonded particle boards are less popular (Saad et al., 2025).

2. Single-family residential construction in Poland

The number of new residential buildings in Poland is increasing every year. The vast majority of these are single-family homes. The number of new residential buildings completed in individual years, broken down into single-family and multi-family buildings, is presented below (Fig. 1).

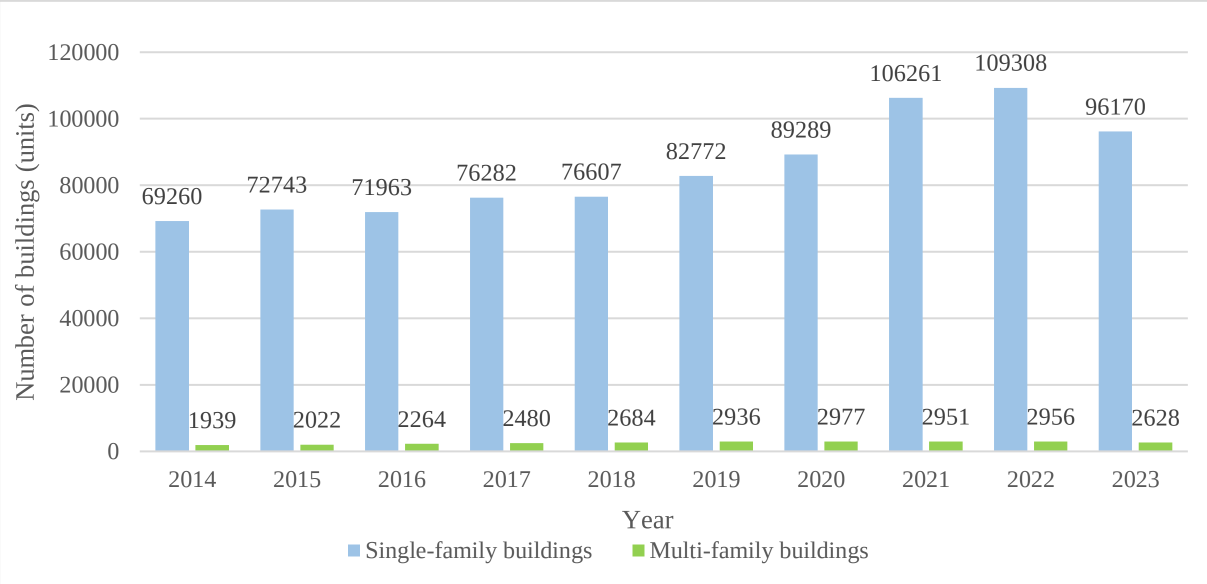


Figure 1. New residential buildings put into use by type of building.

Source: Authors own study based on statistical data (GUS, 2020, 2021, 2022, 2023).

Table 1 presents information on the number of residential units put into use, average usable area and average duration of the construction process in 2020-2023.

Table 1.
New residential buildings put into use in 2020-2023

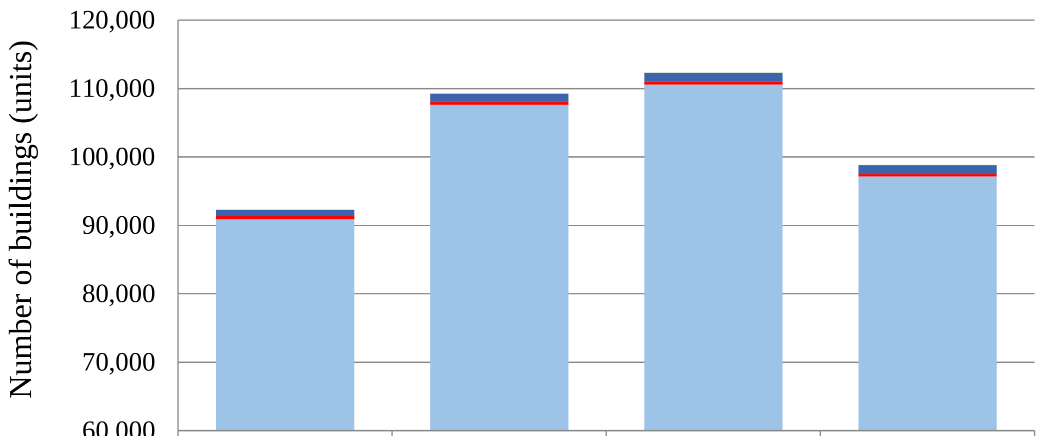
	Type of building							
	Single-family				Multi-family			
Year	**2020**	**2021**	**2022**	**2023**	**2020**	**2021**	**2022**	**2023**
Number of residential units	97245	115457	119575	105566	120536	115709	115545	112678
Average usable area of residential units in sqm	132.3	133.3	131.4	130.7	53.3	52.6	52.1	51.8
Average duration of the construction process in months	46.9	48.5	50.0	51.3	23.6	23.9	24.3	25.0

Source: Authors own study based on statistical data (GUS, 2020, 2021, 2022, 2023).

Contemporary construction utilises many different construction technologies. The number of new residential buildings put into use, broken down into different construction technologies, is shown in Figure 2. The breakdown includes the improved traditional technology, wooden structures and others, including the large panel, monolithic and large block technologies.

In Poland, wooden-framed buildings still make up a small fraction of residential construction. According to data from Statistics Poland (GUS), 1160 such buildings were put into use in 2021 (an increase of 28.2% y/y), which accounted for 1.1% of all residential buildings.

Classification of the construction method as a specific technology is based on the predominant type of structure used in the construction of the building. However, this does not exclude the use of other technologies to a lesser extent. The improved traditional technology is by far the most common in the residential construction sector.



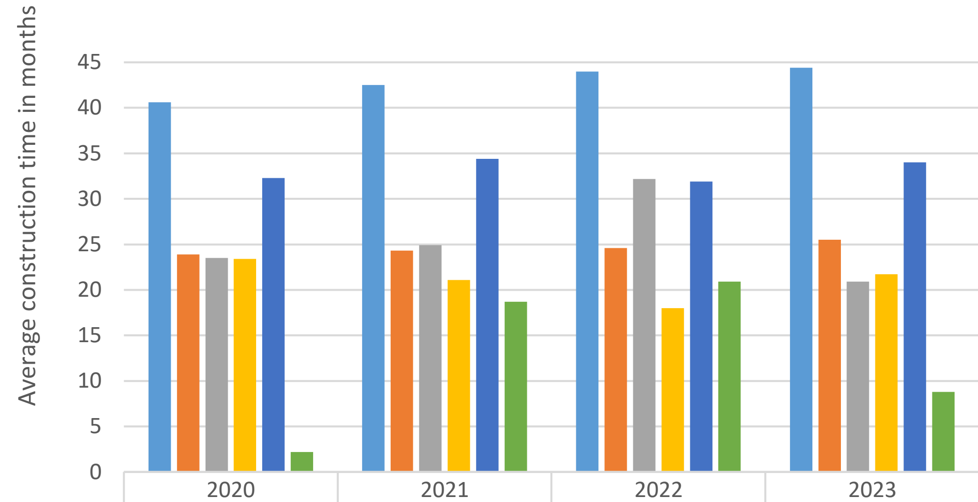
	2020	2021	2022	2023
Other	6	2	11	5
Wooden structure	905	1160	1,261	1303
Large-block	17	10	7	13
Large-panel	13	24	22	24
Monolithic	474	378	354	314
Improved traditional	90,851	107638	110,609	97,139

Figure 2. New single-family residential buildings put into use by erection technology.

Source: Authors own study based on statistical data (GUS, 2020, 2021, 2022, 2023).

Both traditional and concrete-based construction require construction breaks because they involve a lot of wet work, such as concreting, bricklaying and plastering. If these are not observed, moisture can build up in the building, which can result in the growth of mould and mildew. Technological breaks are not only required for masonry work, but also for interior and exterior finishing work. One such example would be the construction of stairs.

Figure 3 shows the average construction time in months by the construction technology used (2020-2023).



	2020	2021	2022	2023
Improved traditional	40.6	42.5	44	44.4
Monolithic	23.9	24.3	24.6	25.5
Large-panel	23.5	24.9	32.2	20.9
Large-block	23.4	21.1	18	21.7
Wooden structures	32.3	34.4	31.9	34
Other	2.2	18.7	20.9	8.8

Figure 3. Average construction time in months by construction technology.

Source: Authors own study based on statistical data (GUS, 2020, 2021, 2022, 2023).

The chart below shows the number of newly constructed single-family residential buildings in a particular calendar year, built with the use of the wooden structure technology (Fig. 4). The chart also shows a rising trend line over the period analysed. This proves the growing popularity of building with this technology and determines the direction of development of the single-family construction sector.

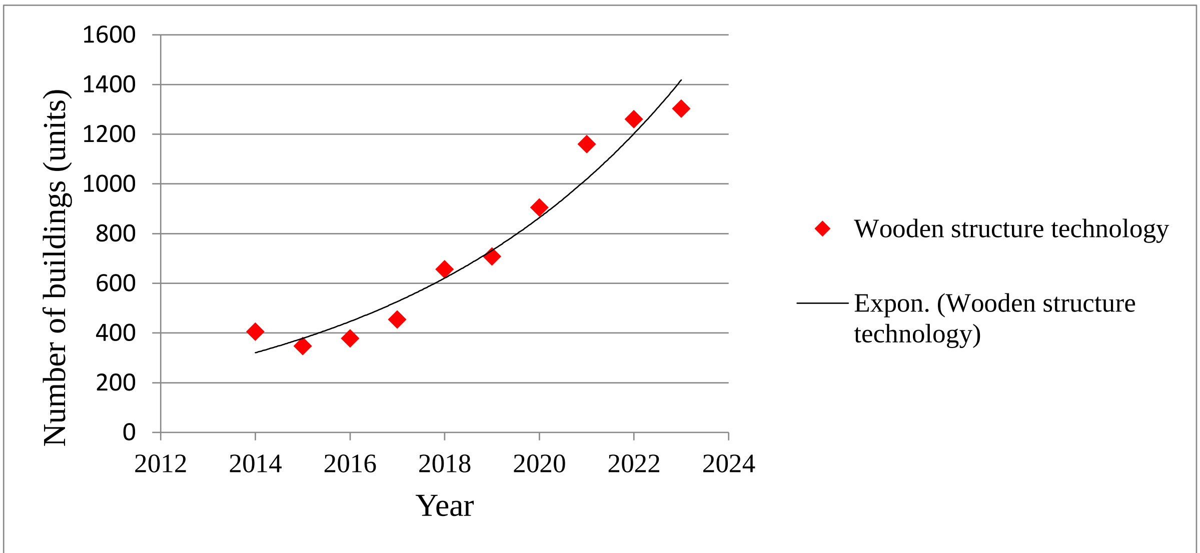


Figure 4. New single-family residential buildings erected in the wooden structure technology.

Source: Authors own study based on statistical data (GUS, 2020, 2021, 2022, 2023).

According to the report "Modular Construction in Poland 2024-2029" by the research company Spectis, total revenue of the 100 largest manufacturers of prefabricated buildings made of wood, steel, concrete and expanded clay concrete amounted to around PLN 10bn in 2022, of which 47% was generated by sales in the modular building segment (Fig. 5) (Forum-holzbau.pl, 2023). Nominal change (%, y/y) is shown in the figure.

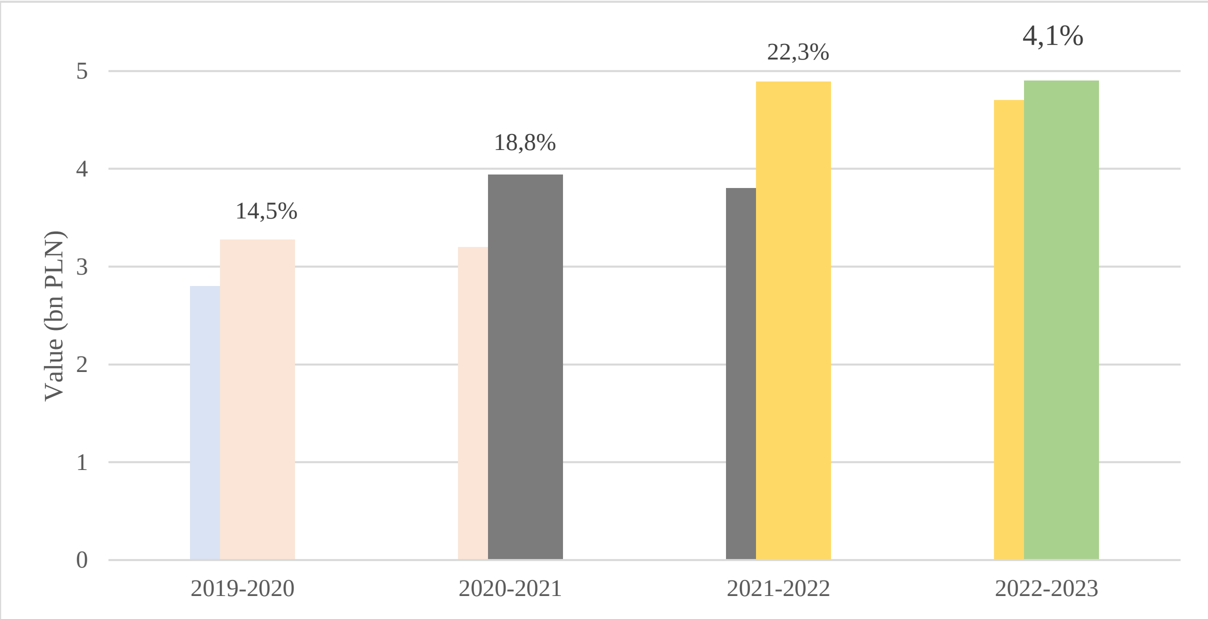


Figure 5. Modular construction market in Poland.

Source: Authors own study based on statistical data (Forum-holzbau.pl, 2023).

The demand for construction timber is increasing, while its harvesting has been limited in recent years. As a result, there are more and more shortages of this raw material (Forest Europe, 2020).

The production technology of prefabricated houses is based on the manufacturing of finished elements, i.e. main walls with window carpentry, load-bearing walls, ceilings, roof trusses, in dry conditions in a production hall. The main raw material used is renewable construction timber, boards or wood panels, the production of which generates significantly lower CO2 emissions than the production of common building materials. The timber used is dry (its moisture content does not exceed 15%), which means that there is no possibility of its volume changing. Figure 6 shows the annual volume of timber harvested, excluding firewood. An increasing trend in the exploitation of timber resources can be observed until 2018, when the amount of raw material obtained was the highest, reaching over 44,590,000 m^3. According to Eurostat, in recent years Poland has consistently ranked fifth in terms of annual timber harvesting.

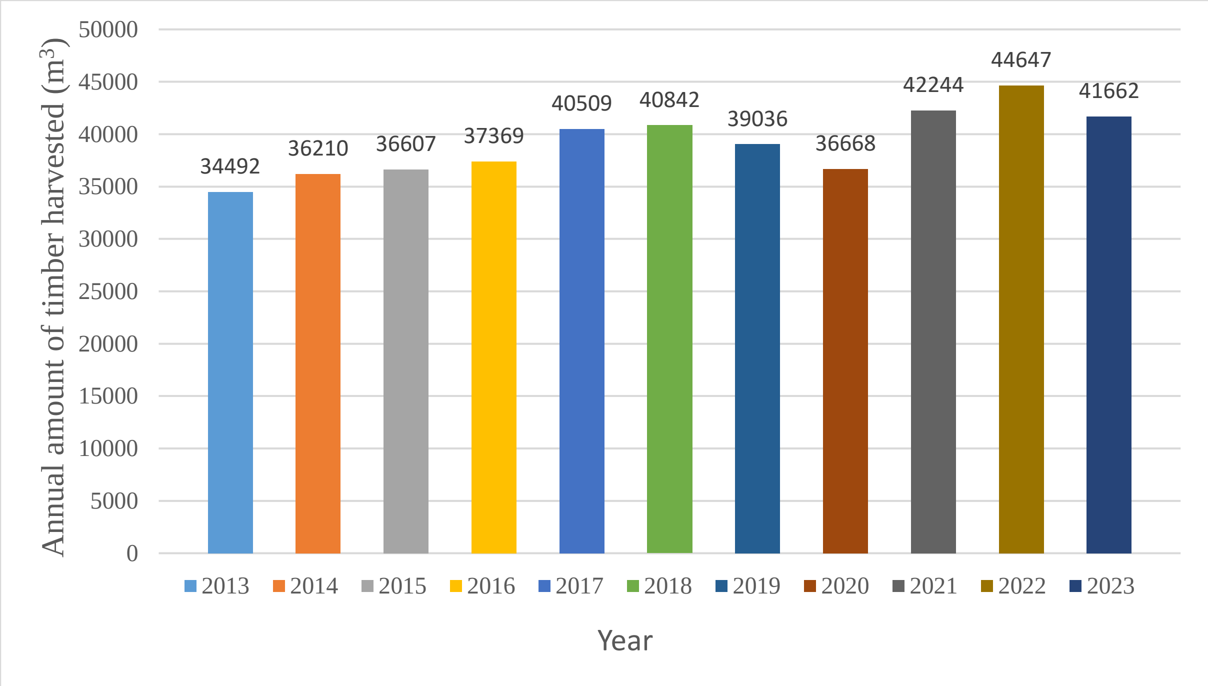


Figure 6. Annual amount of timber harvested in Poland in thousand m^3.

Source: Authors own study based on statistical data (Eurostat, 2025).

3. Case study

The case study was produced based on data obtained from a company that designs and produces prefabricated residential buildings, technical specifications from a manufacturer of machinery used at the production plant, and on the basis of our own observations.

Implementation of a detached house design begins with a surveyor marking out the site where the house is to be built according to the coordinates specified in the design. Then, almost simultaneously, work begins at the construction site and at the production hall. The first task at the construction site is to install the power, water and sewage connections. Then, the access road and the area where the building is to be erected are hardened. After that, a foundation slab is created, which will form the basis of the building. The process of manufacturing the modules that will make up the building starts at the production hall. The structure consists of external walls, internal walls, ceiling modules and roof panels. The operations are performed using specialised CNC machines that ensure accurate material processing. Thanks to automation of the production line, serial production is possible.

The production of prefabricated elements takes place in controlled conditions on the production floor. The diagram shows particular stages of the production process using the example of construction of an exterior wall (Fig. 7).

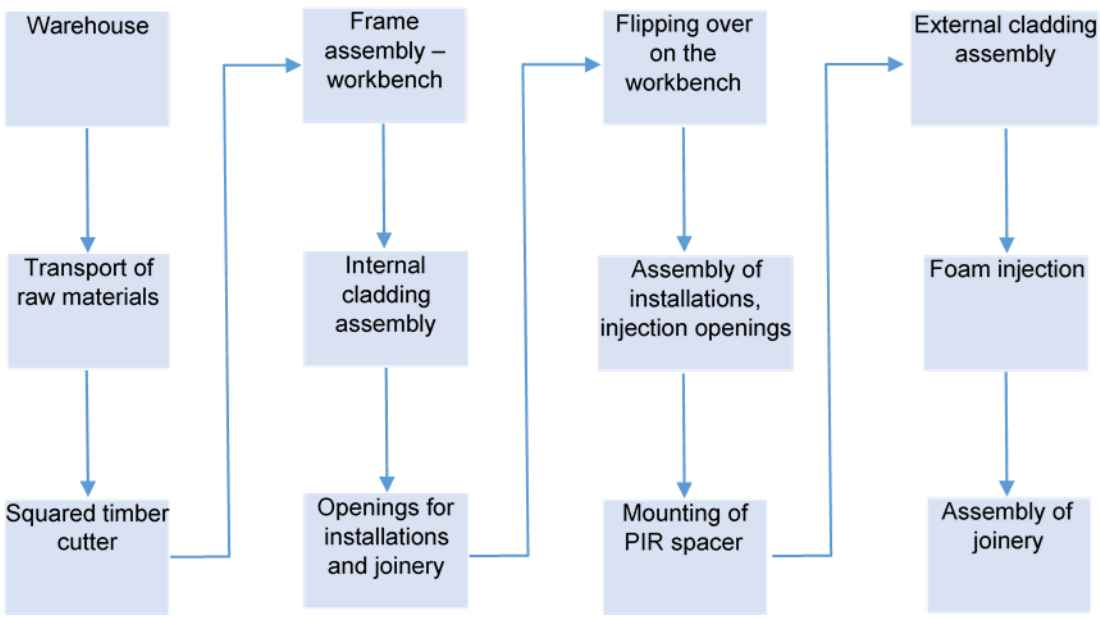


Figure 7. Diagram of the prefabricate production process for a residential building external wall.

Source: Authors own study based on data obtained from the production plant.

The production process commences with the machines being set up according to the design. Then the materials are transported from the warehouse to the production hall and arranged in such a way that the material to be used is as close as possible to the workstation where it will be processed. The first processing step is carried out at carpentry centre No. 1 and includes cutting the squared timber and making the designed notches and rabbets. Then, the processed elements are transferred to workbench No. 1 and assembled into a frame, which constitutes the skeleton of the partition. The individual elements are attached using pneumatic nail guns (Fig. 8a). Next, the inner sheathing is installed at carpentry centre No. 2 (Fig. 8b). After installation of the sheathing, holes are made for different installations (Fig. 8c) and the places for the window and door joinery are cut out. Next, the wall is flipped over its long side onto workbench No. 2, where the plumbing (Fig. 8d) and electrical installations are installed. Injection holes are also made. Then a hard PIR foam spacer is mounted on the wall skeleton, on which the external cladding is mounted using carpentry centre No. 2. Then, foam is injected into the interior of the wall, which is placed in a press to prevent excessive expansion of the insulator (Fig. 8e). The production process of the prefabricated wall is completed by installation of window and door joinery (Fig. 8f).

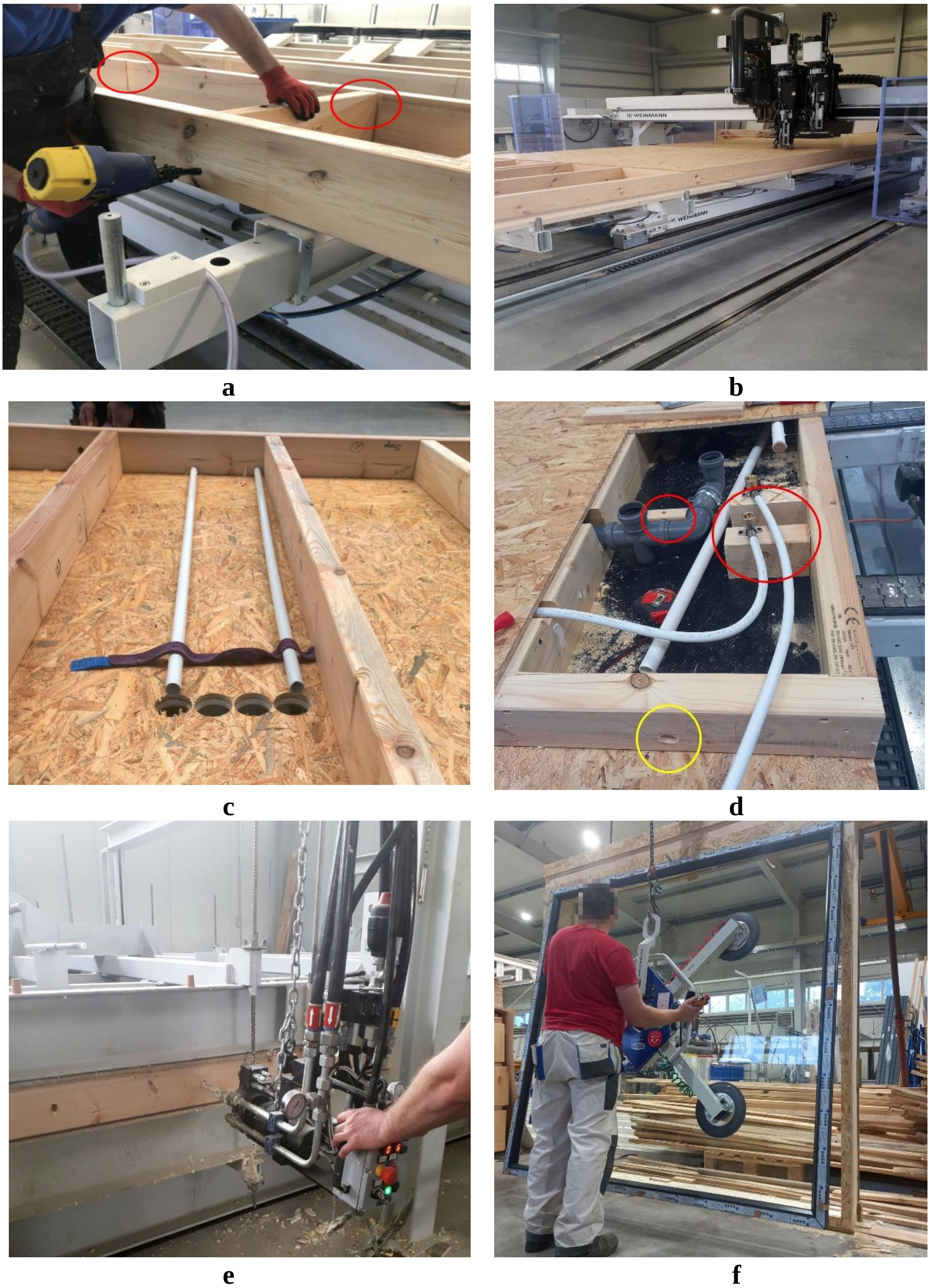


Figure 8. Production of prefabricates: a – construction of the wall frame using a pneumatic nail gun; b – automatic attachment of panels using carpentry centre No. 2; c – installation of electrical wiring piping; d – installation of water and sewage systems; e – process of polyurethane foam injection; f – Installation of the window in the external wall.

Source: Authors own study based on data obtained from the production plant.

Works at the construction site start at the same time as the production process. The diagram below illustrates the individual stages of building construction (Fig. 9).

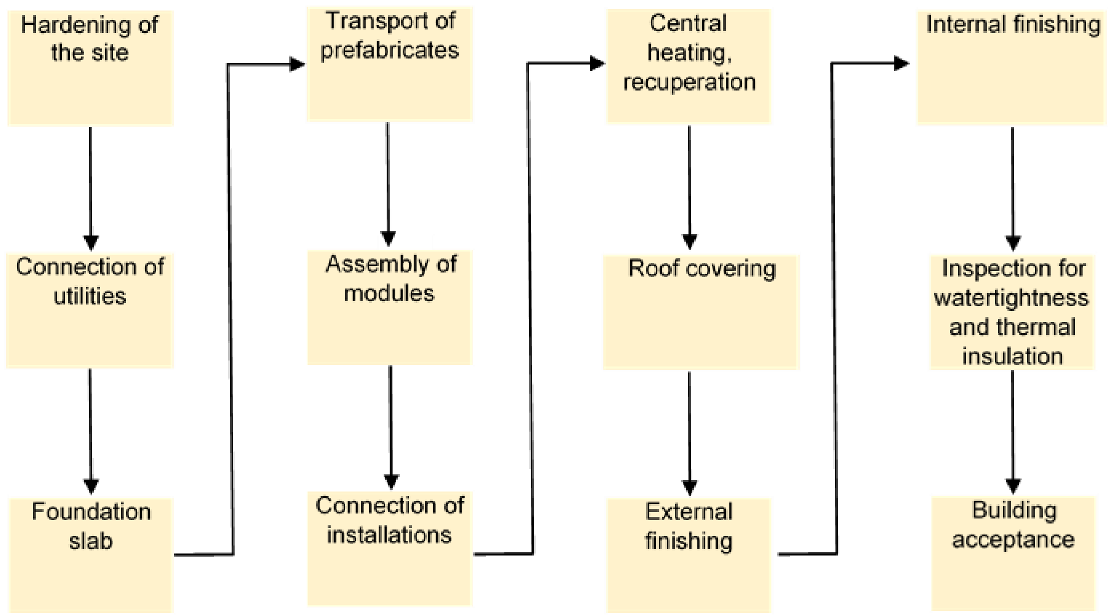


Figure 9. Diagram of works as the construction site.

Source: Authors own study based on data obtained from the production plant.

The first step is installing the necessary utilities at the construction site. Then, the area is prepared and the foundation slab is laid (Fig. 10a). The next step involves transporting prefabricated parts to the construction site (Fig. 10b). The walls are attached to the foundation using a crane (Fig. 10c), and the floor and roof are attached to them (Fig. 10d). In the next step, all installations are connected. In addition, a central heating system with a heat pump and a mechanical air recirculation system – recuperator – are connected. At the same time, the workers install the roofing. The next stage involves interior finishing work – installing the suspended ceiling, preparing the walls for painting and painting them, installing sockets and switches (Fig. 10e). At the same time, finishing work is being carried out on the outside of the building – completing the façade, laying the foundation perimeter around the building and preparing the entrance with paving blocks (Fig. 10f). The final stage is inspection of the building for watertightness and thermal insulation. Once the test is positive, building acceptance is carried out, after which the building achieves the builder's finish status.

The analysis revealed the problem of production waste management. Based on the above, assessment of the production of prefabricated wooden houses was carried out and ways of managing production wood waste were suggested.

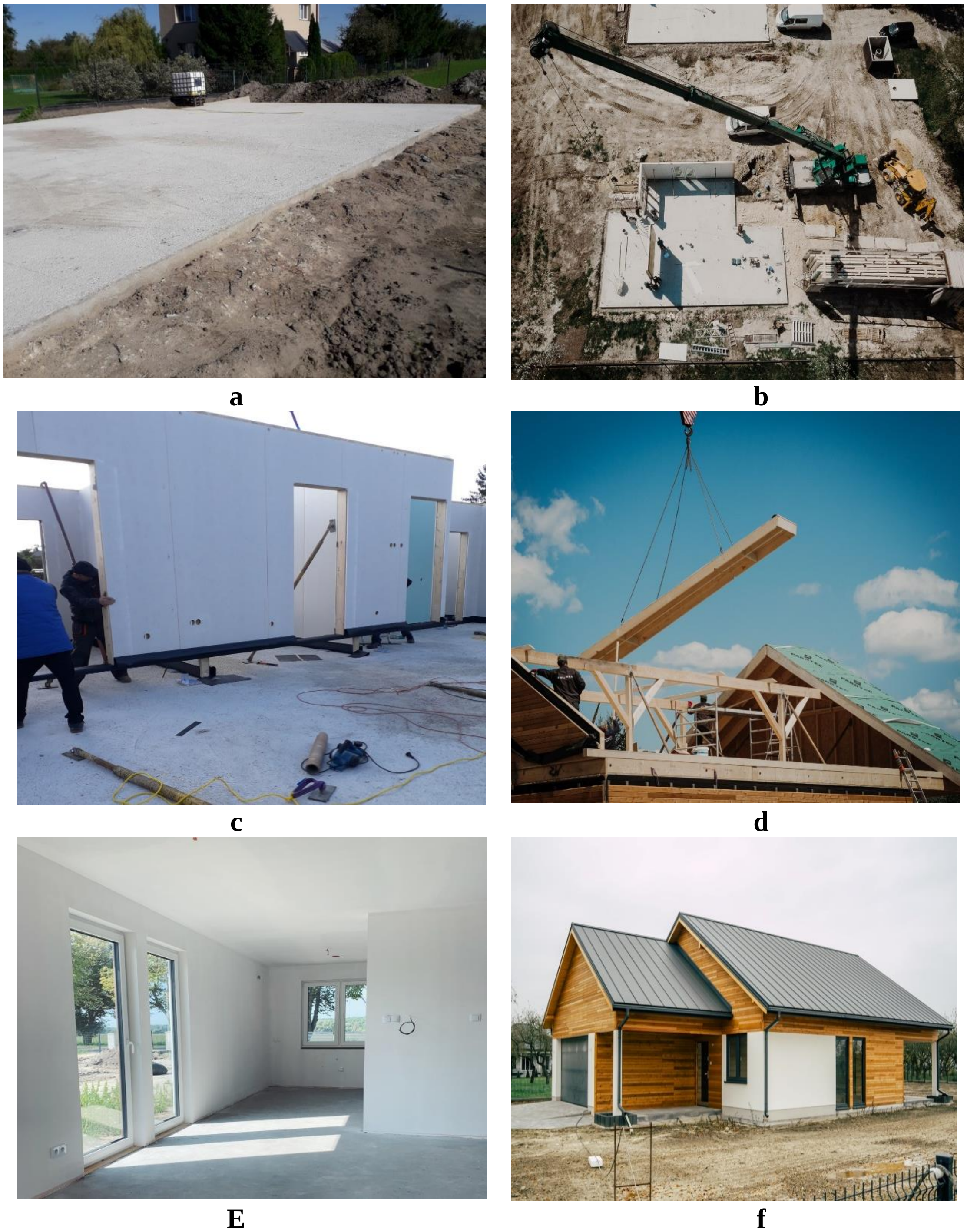


Figure 10. Production of prefabricates: a – finished foundation slab; b – process of module placement; c – installation of a prefabricated module; d – installation of a roof panel; e – view from the interior of a finished house; f – finished building constructed in the wooden modular structure technology.

Source: Authors own study based on data obtained from the production plant.

Analysis of the prefabrication process revealed a problem with production waste management. Specifically, wood waste that could be recycled or used as fuel is disposed of together with other waste. This is handled by a third party company. This solution is uneconomical and not environmentally friendly; a different way of dealing with this type of waste should be considered.

3.1. Production waste management

Waste generated during the production of prefabricated elements at the analysed company can be divided into two groups. The former includes natural wood waste that can be safely recycled and waste that contains harmful substances such as adhesives or resins, or is artificial in itself, such as electrical cable sheaths or water and sewage pipes. Wood waste includes sawdust from sawing wood, shavings from drilling holes, pieces of wood of various sizes that are too short as well pieces of wood from notching and rebating. Waste that can be classified in the second group includes pieces of OSB board containing adhesives, cut off residues of dried PUR foam, short sections of water and sewage pipes, electrical cable sheaths, pieces of roofing membrane and wind insulation foil, residues of rigid polyurethane foam, and pieces of plasterboard.

The company does not currently process any waste. The waste is not stored or sorted. It is removed from the production hall by a conveyor belt that collects sawdust and shavings from the carpentry centre, a sawdust extractor that collects sawdust from various stations and transports it to one place, and a container into which pieces of construction wood, OSB and plasterboard, foam residues, pieces of foil and other kinds of production waste are thrown (Fig. 11). All waste is then placed in one container, which is periodically taken away from the plant.

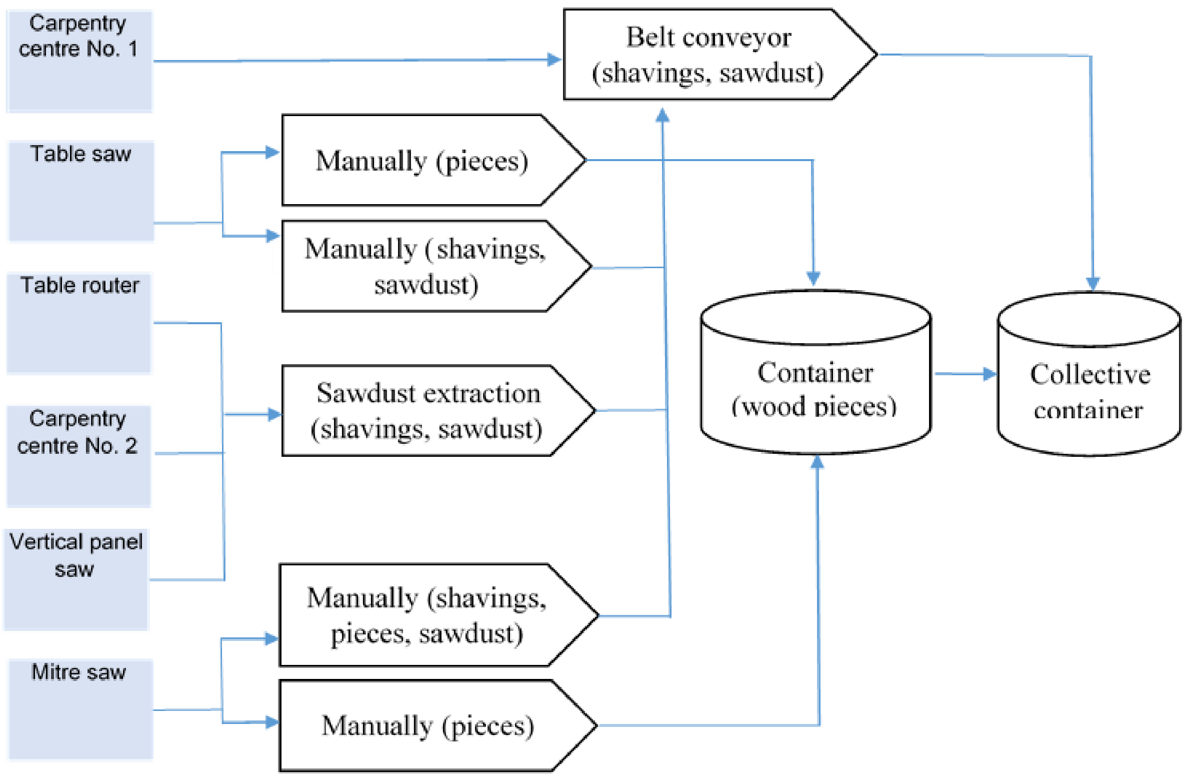


Figure 11. Current waste management system of the production plant.

Source: Authors own study based on data obtained from the production plant.

The company outsources its waste management to a third party, which collects unsorted waste in return for payment. This solution is not environmentally friendly and generates costs that could be minimised. The sorting of waste alone would reduce disposal costs. The production hall is equipped with a central heating system. The heat is generated by a solid fuel boiler, which the company keeps stocked with fuel. By choosing to sell the waste, the company could use the funds from the sale to purchase fuel. By choosing to recycle production waste, the company can become self-sufficient in terms of heating by using the fuel it produces itself. This eliminates the middlemen who add a significant mark-up to the price of the final fuel. This waste management solution can bring measurable benefits.

The production of prefabricated houses generates clean wood waste in the form of sawdust, shavings and solid wood pieces. The production of a 140 sqm house takes on average 12 days, assuming a daily working time of 10 hours and no interruptions due to breakdowns or unavailability of materials. Therefore, an average of two houses can be produced in a month at the company under review. Due to the fact that the line is highly automated, production does not generate a large amount of wood waste.

Companies buy specific types of wood waste. Most of them are interested in purchasing shavings, sawmill residues or ready pellets. Only a small group of companies is interested in production waste. In addition, they are reluctant to work with companies that generate small amounts of waste. One can conclude that sale is not an appropriate way to manage the waste of a company conducting this type of activity.

In order to save money, the company may consider purchasing a wood pellet production line. Wood used to make the prefabricated elements is coniferous wood with a high lignin content, which acts as a binder during pellet production. The wood used has the desired production parameters, with a moisture content of no more than 15%. As a result, the product manufactured could be high in calories and of a good quality, which is crucial for an efficient combustion process. Pellets are a biofuel that releases much less carbon dioxide during combustion than other solid fuels. In addition, the structure and good quality of the granules guarantee a fairly low ash production.

Selection of the above waste management method is justified by the nature of the company's production and the economic aspect of modernisation. Considering that the production hall is heated by a solid fuel boiler, it is possible to replace it with biofuel in the form of wood pellets. Thanks to this waste management model, the heating costs of the facility, which are currently constantly increasing, will decrease significantly. The method of heating with this biofuel is also characterised by lower exhaust emissions, meeting the required European standards, which has a positive impact on the environment.

3.2. Financial potential of the sector of prefabricated buildings

Prefabricated buildings are used to construct other structures. They can be made of various materials, including wood, steel and concrete. According to the Observatory of Economic Complexity (OEC), in 2022, prefabricated buildings ranked as the 326th most traded product in the world, with a total turnover of USD 12.2bn. In 2021-2022, exports of prefabricated buildings increased by 13.1%, from USD 10.8bn to USD 12.2bn. The trade in prefabricated buildings accounts for 0.052% of total global trade. In 2022, the largest exporters of prefabricated buildings were China (USD 2.73bn), the Czech Republic (USD 635m), Estonia (USD 601m), the United States (USD 566m) and the Netherlands (USD 542m). In 2022, the largest importers of prefabricated buildings were Germany (USD 1.54bn), the United States (USD 816m), France (USD 605m), Hong Kong (USD 554m) and the United Kingdom (USD 547m).

After Estonia and Lithuania, Poland is the third largest exporter of prefabricated wooden houses in the EU. The export value reached EUR 115.1 m in 2021, recording a high growth rate (+52.7% y/y). The largest recipients of prefabricated wooden houses from Poland are Germany, the UK and Norway.

According to data from Statistics Poland (GUS), there are about 580 companies actively building in the wooden technology (including about 30-40 manufacturers of modular houses) and about 260 companies building log houses in Poland. Polish companies are also active on foreign markets – according to the report "Wooden construction as a stimulator of housing development in Poland" (Wood Technology Institute, Poznań, 2020), Polish companies build about 4,000 houses outside Poland, mainly in prefabricated frame technology.

The prices of modular houses vary from PLN 1000 per sqm up to as much as PLN 7000 per sqm and they depend on many factors, including the finishing state, type of building materials or topography of the plot where the finished house will be built. This results in a wide range of prices per square metre.

4. Summary and discussion

Construction is a rapidly developing branch of the heavy industry. Considering the aforementioned materials and processes, one can conclude that the construction industry has undergone a radical transformation over the past decades. Nowadays, the industry is shifting away from monolithic and large-panel technologies.

Due to the growing population and increasing housing shortage, more and more residential buildings are being constructed every year. Currently, the improved traditional technology which, despite constant modernisation, still consumes huge amounts of energy and materials is the prevailing building erection method. In the era of high prices of construction materials and services and fast pace of life, there is a growing interest in technologies that prioritise production speed and economical use of materials. In response to market needs, buildings are erected using prefabricated modules based on a wooden frame. A building erected in this technology is ready for use approximately three months after launching the investment.

The production plant under review designs and produces prefabricated wooden houses. The construction of such a building is based on modules with a wooden frame, such as the external and internal walls, ceilings and roof panels.

Compared to the traditional bricklaying method, buildings constructed using this technology are built very quickly. The production time for prefabricated parts is around 12 days, the house is completed in a maximum of 3 days, and it takes around 3 months to complete the builder's finish condition.

The paper discusses the possibility of managing production waste. The modernisation involves recycling and reusing production waste in the form of uncontaminated wood: sawdust, shavings and pieces of squared timber. Currently, the company outsources waste management to a third party, incurring significant costs that will increase over time due to stricter waste disposal regulations and the degree of pollution of the planet. The modernisation would involve addition of a wood pellet production line. This form of recycling was chosen because of favourable conditions in terms of properties of the waste. Namely, the waste comes from the processing of KVH wood, which is coniferous. Softwood contains a lot of lignin, which is necessary in the pelletisation process because it acts as a kind of binder. According to the literature, good quality pellets should have a maximum moisture content of 15%. The wood mentioned above has the same characteristic and, therefore, offers great potential for the production of solid, concentrated biofuels. The company uses pellets to heat the production hall. It obtains this fuel on the market, where prices are constantly rising due to high demand and high logistics costs. In fact, pellet production is not that expensive.

Building with wood could become part of Poland's housing policy. Although it currently represents a small segment of the housing market, the share of wooden houses is likely to increase within a few years. The key limitation to the development of wooden construction in Poland is still low public awareness of the advantages of such structures.

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