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1. Introduction

Housing is an essential element in everyone's life. The most commonly inhabited facilities are blocks of flats, tenement houses, single-family or multi-family houses. Over time, developing technologies in the field of construction allow faster and more efficient construction solutions, which contribute to more effective satisfaction of housing needs. Based on an analysis of the literature, the following technologies used in housing construction can be distinguished:

- monolithic construction technology uses a frame structure usually made of reinforced concrete or concrete. To use this technology, formwork - planking is used. It is possible to use them repeatedly and implement plans with different construction features (Główny Urząd Statystyczny, 2024);
- prefabricated metal technology

 prefabricated components are manufactured in steel mills so that they are suitable for transportation by land or water. Manufactured semi-finished components are transported to the construction site,

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where appropriately specialized personnel are engaged in assembling the structure (Runkiewicz et al., 2020, pp. 13-14);

- prefabricated wood technology uses wooden elements, with the help of which it is possible to obtain various shapes of buildings, and is highly durable and environmentally friendly. Used in the creation of trusses and roofing, but also in the construction of other elements of the property (Runkiewicz et al., 2020, pp. 13-14),
- bricklaying technology one of the oldest construction techniques involving the construction of walls in such a way that the gaps between bricks or blocks are filled with mortar. Typically, in this technology, structures are made of lightweight materials and low heat transfer coefficient (Rzeszowska, 2018, pp. 342-346);
- tall building technology with this technology special attention is paid to the weather conditions that usually affect tall structures. The building must be durable, and at the same time flexible and resistant to wind and vibration. Most often, prefabricated metal and reinforced concrete elements are used for construction;
- mixed construction technologies different building and construction technologies, as well as different integrating and cushioning materials (Wójcik, 2010, p. 7).

2. Characteristics of modular technology

In recent years, another technology has begun to attract particular interest, namely modular technology, which is considered environmentally friendly, relatively cheap and quick to implement. This construction solution in common parlance is defined as a modular system in construction, which is most often associated with a block (with dimensions a, b, c), very often a popular shipping container used primarily for transporting heavy materials. The design of traditional shipping containers is standardized, adapted to the function they perform . Moreover, according to Hernandez (2019), modular technology is a construction method consisting of modules, the production of which takes place in a controlled factory environment. The components are then transported to the construction site, where foundations have previously been created, or a podium on which the modules are set (Klochko, 2022). In order to better visualize the module production processes, nine stages of the process can be distinguished:

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- design in BIM (Building Information Modelling) taking the necessary information from investors and users and thus understanding their preferences and the target use of the building, enabling the transition to the design of fully functional and aesthetic modules;
- production of floor and ceiling modules;
- production of wall modules an automatic process that involves cutting the appropriate elements from wood or steel panels, taking into account the ventilation holes. At this stage, the elements are filled with mineral wool in accordance with fire and acoustic requirements;
- asssembly of modules during this stage, electrical, heating and ventilation systems are installed, as well as windows, doors and radiators;
- finishing work customer preferences for painting, tiling or laying parquet floors are taken into account;
- installation of kitchen furniture and bathroom fixtures all furniture and household appliances are installed in accordance with customer requests;
- transportation of finished modules the manufactured modules are secured and transported by land or water to the installation site;
- assembly of the modules on the construction site arranging the modules on the previously prepared foundations in accordance with the designs and plans, securing them, merging them with each other, and finally laying the external elevations;
- finalizing making minor adjustments and transferring to the owners.

Particular attention should be paid to the mobility of the work performed. A significant part of the production stages takes place in fully controllable conditions, i.e. in closed hangars, where all construction work can be carried out. Atmospheric conditions do not affect the course and timing of work on the creation of modules. The only sensitive stage is the eighth stage concerning the assembly of modules on site.

3. Factors shaping demand on the modular apartments market

The shaping of interest (potential demand) in any product depends on the features of the product itself and consumer needs. In the case of modular housing, it is important to know the characteristic aspects of this type of property. Modular technology is characterized by a number of advantages that support its use in more and more construction projects. The main advantages include functionality - the modularity of the elements, which makes it

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possible to give the apartment any shape, style and design. (Ojo-Fatore et al., 2018) It also allows any development of the plot and the arrangement of individual segments. The investor can freely develop the space of modular apartments, taking into account the convenient functionality, room design and the arrangement of individual modules on top of each other or one next to the other in such a way as to most satisfy his housing and visual needs. (Szuba, 2022, pp. 9-13) Among the advantages of modular construction that the investor can point out are:

- material saving in the production of the module, the number of necessary structures and construction waste is minimized, due, among other things, to the fact that much of this waste is steel and can be reused (Szuba, 2022, pp. 16-20);
- eco-friendliness during the production of individual components, natural materials such as stone and wood are used. Passive solutions related to heating, heat recuperation and cooling are used relatively often. It is also possible to create additional green areas on the roofs of buildings;
- energy efficiency the walls are created in such a way as to extract heat from solar energy and then store it in underground heat storage batteries. Modular houses are characterized by precise thermal insulation, with the help of which it is possible to maintain high indoor temperatures for longer. Often photovoltaic panels are installed directly on the roof of the building or within the plot (Szuba, 2022, pp. 19-20);
- construction time the production and installation of a modular apartment is much shorter than building in traditional technology (figure 2). On average, the duration of a modular project takes from 3 to 6 months. In contrast, constructing a house in the traditional way is estimated to take 1-2 years. Traditional forms of real estate construction are associated with necessary downtime if only due to adverse weather conditions, such as late autumn or winter. In the case of an innovative form of housing construction, such as modular technology, downtime can be ruled out, as the technology allows work in low temperatures and adverse weather conditions. An important issue in modular construction is the simultaneous acquisition of building permits and performance of foundation work while creating prefabricated elements that form the body of the building. This significantly shortens the construction process compared to traditional construction methods (Bielenia, 2021, pp. 17-19);

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- mobility it is possible to change the location of the property. It is necessary to disassemble the apartment into individual modules and transport them to a new location, on which the foundations were previously prepared (Szuba, 2022, pp. 3-13);
- applicability modular technology allows the creation of new premises in a relatively short period of time while maintaining good utility, thermal insulation and energy-saving conditions, and the technology can be used in residential construction (small apartment houses, multi-family houses, seasonal or year-round recreation facilities), public utility construction (office pavilions, catering facilities, tourist information buildings, locker room and sanitary facilities in the space of sports and recreation facilities, service and commercial facilities, facilities for cosmetic and hairdressing services, etc.), construction of a technical nature (trafo stations, storage facilities, cold storage facilities. (Szuba, 2022, p. 21)

Based on the factors presented, it can be concluded that modular housing could seem like an ideal solution to meet many social and service needs. However, it is important to point out disadvantages that could hinder investment decisions:

- prepaid investment when placing an order for the implementation of modules, the investor must be prepared to pay for the entire investment upfront. This means that those involved cannot successively plan the construction process and spend capital in a systematic way;
- lack of personal selection of components unlike the traditional construction process, the components and materials needed for the apartment are imposed from above;
- conditions regarding the location of the plot due to the need to transport prefabricated elements by truck and the presence of a crane on site, easy access to the land on which the foundation was previously prepared must be provided. Difficulties for development companies are wetlands and those to which there is no paved access road (Bobbe, 2020).

Taking into account the analysis conducted, the possibilities of investing in modular housing can be presented on the basis of a simple comparative analysis of the strengths and weaknesses, as well as the opportunities and threats that may be associated with it (table 1).

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Table 1	I. Analysis of strengths, weaknesses, opportunities
	and threats regarding modular housing

Strengths	Weaknesses
 possibility of moving buildings due to relatively easy disassembly and reassembly of modules, possibility of enlarging the building's volume by installing additional modules, preparation of modules in the production plant, which will enable obtaining the appropriate quality of elements and buildings regardless of weather conditions, permanent experienced crew guaranteeing: control of the materials used and high quality of modules at every stage of their production, short implementation time, thus reducing construction costs, repeatability of design solutions facilitating their proper execution, ease of combining a modular system with a monolithic one, lower costs of maintaining and maintaining facilities, increased load-bearing capacity and durability of the structure (less deflections) through the use of higher-class concrete, possibility of use in crisis situations - modular technology allows you to quickly create housing and office conditions in sudden and unexpected situations, e.g. an intensified influx of refugees. 	 architectural limitations - designs of such buildings are a challenge for the architect, high costs and major technical limitations in changing the internal layout of the apartment, difficulty in changing the arrangement and internal space, which predisposes it to certain types of buildings, e.g. hotels, schools, kindergartens, the need to use a crane or other means of vertical transport to assemble the building, limited range of cost-effective transport of modular elements,
Opportunities	Threats
government housing programs,modern technologies and materials,	 problem with financing construction projects, scattered construction locations, which affects

- digitization of construction (BIM).
- transport costs and logistics,lack of appropriate materials and technological
- solutions,
- dependence on foreign decision-making centers of enterprises operating on the Polish construction market.

Source: Bartkowiak et al., 2024, pp. 87-88

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4. Comparison of the prices of modular apartments with the prices of traditional apartments

One of the most important issues to consider when making investment decisions in residential real estate is the price of the property. In recent years, the housing market in Poland, but also more broadly in the European Union, has been subject to very dynamic fluctuations. The dynamics of price changes in the housing market in Poland are among the highest in the EU member states. Poland, compared to other European countries, is still struggling with the problem of low housing saturation and relatively low housing affordability. Constantly rising prices of materials, the housing shortage and high interest rates make it difficult for the average citizen to buy an apartment. It is therefore necessary to look at the average purchase prices of apartments on the primary market and the cost of building modular housing (figure 1).



Figure 1. Average transaction prices (in PLN thousand per m²) of dwellings on the primary market in the 6 largest cities in Poland in the fourth quarter of 2023

Source: own study based on Narodowy Bank Polski, 2024

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In order to provide a better overview of the market, three groups of dwellings have been distinguished based on the criterion of floor area: 1) dwellings up to 40m², 2) dwellings from 40.1m² to 60m², and dwellings from 60.1m² to 80m². The selected property sizes reflect consumer preferences currently on the market, and are also the same as those found in statements compiled by the Central Statistical Office (GUS) and the National Bank of Poland (NBP). In order to objectively assess the situation on the primary market, average transaction prices per m² in the six largest Polish cities were analyzed. Taking into account the available data, it can be concluded that:

- regardless of the area of the dwelling, the highest prices per m² are in Warszawa;
- regardless of the area of the apartment, the lowest prices per m² are in Łódź;
- the price per m² of dwellings up to 40m² are on a similar level in Gdańsk, Kraków and Wrocław. The average price per m² is understated in Łódź and Poznań, while it is significantly overstated in Warsaw.



Figure 2. Average transaction prices (in PLN thousand per m²) of apartments on the primary market in the 6 largest cities in Poland in the fourth quarter of 2023.

Source: own study based on Narodowy Bank Polski, 2024

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In order to conduct a comparative analysis of prices of housing built in traditional technology and modular technology the total prices were calculated (figure 2). To do so, the average prices of dwellings in primary market in six largest Polish cities were used. It was assumed to calculate the total prices for the hypothetical dwellings with an area of: 40m², 60m² and 80m². To calculate the total prices of modular housing the prices taken from the relevant sources – available listings of modular houses were used. The same usable area of dwellings were assumed. In turn, figure 3 presents the prices of modular dwellings (the price per square meter was averaged). The collected data concerns the primary market in a development state. The price of modular dwellings was estimated in relation to the square area of individual dwelling. The price of the modular housing also included the cost of preparing and constructing the foundations (estimated on the basis of



Figure 3. Comparison of prices of apartments (in PLN thousand) built using technologies commonly used by developers in the 6 largest cities in Poland with modular apartments

Source: own study based on the Narodowy Bank Polski, 2024; Watradom, 2024 (estimates of foundation costs)

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a valuation from one of the contractors) and the price of the land, which in both variants (traditional and modular technology) was assumed to be 21% of the total cost (figure 4). The largest share of the total cost of the traditional housing is the construction cost at 51%, which decreases significantly with the modular housing.



Source: Palicki & Strączkowski, 2019, p. 107.

The analysis shows that modular housing is relatively cheaper than dwellings built in traditional technology in all Polish cities analyzed. Therfore, modular housing can be considered as an alternative in meeting housing needs. Taking this analysis in mind, it can be assumed that the lower price of modular housing construction may have a positive impact on the interest in modular housing in the near future.

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5. Methods

As noted earlier, the main objective of the study is to assess the level of interest in modular housing. To achieve this goal, a survey was conducted. The tool that was used was an online survey questionnaire. The methodology of the survey conducted is presented in table 2.

Specification	Description
information collection time	February 2024
spatial scope of the study	the study was addressed to companies operating in the Wielkopolskie Voivodeship
material scope of the study	 interest in modular housing age of customers who are relatively most interested in modular apartments ability to meet housing needs through modular housing
time scope of the study	years 2021-2023
research tool	online survey questionnaire
selection and sample size	 non-random convenient sampling. sample size - the form was sent to 234 companies related to the real estate market: employees of companies producing modular housing, developers and real estate agents ultimately a return rate of 22% was achieved, i.e. n=51 surveys.

Table 2. Information about the study

Source: own study

Respondents made choices of strictly defined response options within the framework of closed questions. The structure of the questions and answers in the survey resembles the construction of questionnaires used in diagnosing economic prosperity using the so-called economic test or business cycle test which focus on identification of consumers and producers confidence. According to the literature, this is a method that allows, among other things, to determine activity in the industrial sector (e.g. industrial production) or the sentiment of producers or consumers. Surveys are composed of questions with a 3- or 5-point scale, in which respondents are asked about the direction of changes in a specific research subject. More extensive answers (enlarged scale) are not used, since the basic

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measure in business cycle tests is the so-called balance, defined as the difference between the percentage of answers reporting an increase (improvement) and the percentage of answers reporting a decrease (deterioration). The methodology used has been widely discussed in the literature (Bieć, 1996; Garczarczyk et al., 2001).

The sampling also needs to be clarified. As stated in table 2, non-random convenience sampling was used. It is a kind of combination of typical convenience sampling and snowball sampling. Its use, with full awareness of the limitations arising from it, was dictated by the difficulty of constructing the sampling frame and the nature of the survey, which is to be further deepened. The questionnaire was distributed to 234 subjects. Taking into account the returns and the merits of the material obtained, a set of n=51 questionnaires was finally analyzed. In the structure of the respondents, nearly half (49%) were real estate agents (their participation in the survey is justified by their close contact with customers meeting their housing needs), 33% - employees of companies involved in the product to the market), while 18% were developers (their presence is explained similarly to that of agents).

The following research questions were posed for the research conducted:

- 1. What is the level of interest in buying apartments and houses manufactured with modular technology?
- 2. What factors influence the choice of modular technology when buying housing?
- 3. What is the age of buyers of housing manufactured with modular technology?

6. Results

The first part of the survey was dedicated to assessing interest in modular homes, as well as questions of reported demand and the number of modular housing listings available (supply). As noted, the answers obtained provide evidence of the direction of changes in customer interest, reported demand and the number of listings on the market.

As for the interest in modular homes, the balance value of +51 points shows that there is quite a large increase in 2021-2023 (see figure 5.). Most likely, this is due to the increasing offers of this type of housing, the beginning of discussions around this topic, information about spectacular investments using this technology, such as the construction of the world's tallest modular hotel in downtown Manhattan (United States), which belongs to the AC by Marriott hotel franchise (The tallest hotel..., 2022).

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Figure 5. Assessment of interest. demand and supply in the field of modular houses in 2021-2023 - response balances

Source: own study.

The situation is slightly different in terms of reported potential demand and the number of available listings on the market (labelled as demand and supply on the figure 5) In 2021-2022, the value of the balance was positive at +47 points for potential demand and +41 points for the number of available listings on the market, respectively. These are values indicating increases, while it is worth noting that a marginally higher balance was reported for potential demand. Thus, it can be thought that reported demand has exceeded market supply, which is a positive sign especially for manufacturing companies. However, in 2023, compared to 2022, there were declines in reported demand (balance -30 points) and the number of available listings (balance -18 points). On the one hand, this would seem to be a negative situation for the market. On the other hand, however, it is difficult to make a fully quantifiable assessment when one does not know the exact initial (quantitative) parameters that characterize one side of the market and the other. It is also difficult to determine the real reasons for this condition. Perhaps it is related to the general market situation (economic slowdown, lower investment activity, higher interest rates and lower credit availability). This element could be another research challenge. Overall, however, when all the balances of responses are put together, and the reported demand and

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the number of available listings are taken together (2021-2023), there is some potential for market growth.



Source: own study.

As modular technology and related projects may be regarded as a kind of novelty, it can be assumed that younger people will show more interest. This is confirmed by the results, since according to the survey respondents, buyers up to the age of 35 are the dominant market segment (47%). Subsequent groups of buyers show relatively less interest in buying. Thus, those aged 55 and older account for only a 9% share of overall modular home purchases (see figure 6).

According to the respondents, the development of modular housing is mainly favored by the short development period (65% of responses), lower development costs (49%) and the ergonomics of modular buildings (49%) see figure 5. The first two factors are confirmed by the studies of Lesniewicz

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(2019), Skorupa and Sobotka (2023) and Dominiak (2022). It is also worth noting the fourth most important answer - the growing ecological trend (37%). Given that ecology is now treated as a trend, and especially young people, who are relatively the largest recipients of modular solutions, follow trends and what is fashionable (Czuchaj-Łagód et al., 2020). In addition, a trump card in favor of the "greening of construction" is that construction is treated as a burden on the environment, and in order to try to combat this phenomenon, recycling is growing in importance, both with regard to the use of recycled materials in the construction process and the creation of buildings that can easily undergo this process (Miasto 77, 2023)



Figure 7. Factors influencing the development of modular housing

Source: own study.

The final component of the research was an assessment of how much modular technology can address the housing needs of households. Respondents were asked two questions:

- 4. Is modular technology able to meet society's changing housing needs?
- 5. Is modular technology able to meet society's housing needs faster than properties built using traditional methods?

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In the case of the first, as many as 73% of respondents answered in the affirmative, with 18% of respondents holding the opposite opinion. In the case of the second, 67% of respondents indicated that modular technology can meet people's housing needs faster. The opposite view was held by 22% of respondents. It is also worth referring to the answer marked in figure 7. The ease of meeting housing needs, which received 35% of responses, is a determinant that it is worth considering the use of modular technology for society's housing needs.

7. Discussion

The research results obtained make it possible to answer the research questions posed. First, young people (up to 35 years of age), are relatively more likely to choose modular housing than people above this age. Secondly, taking into account ecological trends and the necessity of using pro-environmental elements in construction, it can be assumed that the formation of demand for modular housing is closely related to the ecological trends prevailing among the public, in addition, of course, to the unquestionable advantages of this type of technology, which saves time and construction costs. Third, according to the respondents, modular housing makes it possible to meet society's flexible housing needs more quickly. According to the study's authors, this is in line with the changes observed in technology and the market. Already the refugee crisis, following the military action in Ukraine, has shown the need to respond quickly to the housing needs of people arriving from across the eastern border. Since the time and cost of building modular homes is lower and the flexibility of application is higher than that of traditional construction, the authors believe that it is necessary to further study of this segment of the housing market, initiate substantive discussions that involve specialists from different areas of science and practice, and spread education about modular technologies.

8. Conclusions

Modular housing is characterized primarily by its modularity. This makes it possible to increase the functional scope of the property and to adjust and expand it in accordance with local law and consumer preferences. An important factor is their ergonomics and eco-friendliness. Modular housing fits into the current ecological trend - the use of renewable energy. The strength

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of modular dwellings is their prefabrication, which allows the manufacture of high-quality products. This process significantly reduces investment time. The positive aspects of modular dwellings are associated with the opportunity to allow dynamic development of the technology, the continuous development of technology and materials, and the digitization of construction (Fangrat & Sieczkowski, 2017, pp. 1-7).

Despite many positive factors in favor of modular technology, it is necessary to mention the weaknesses and risks. The first is the need for a suitable plot of land with access for heavy machinery, i.e. a crane or tractor-trailer. A significant problem is the issue of logistics and the costs associated with the transformation and interior design. One of the main risks of modular investments is their financing, as manufacturers must receive all the capital at the beginning of the investment process. Another includes dependence on foreign decision-making centers. This results in a lack of freedom of action for subsidiaries operating in the Polish market, with the added effect of prolonged lead times and the inability to make certain decisions and design changes. Despite the rapidly developing new technological solutions, not all of them are able to meet the needs of modular construction. This translates, therefore, into making construction work more difficult (Fangrat & Sieczkowski, 2017, p. 4; Bartkowiak et al., 2023).

Abstract

The main purpose of the paper is to assess the level of interest in modular housing in the residential market from the perspective of those involved in the production and sale of houses and apartments manufactured with this technology. The spatial scope of the study covered the Wielkopolskie Voivodeship. The research was conducted in February 2024 using an online survey questionnaire distributed to respondents via email. Three main research questions were posed for the research conducted: (1) What is the level of interest in buying housing manufactured with modular technology? (2) What factors influence the choice of modular technology when buying housing? (3) What is the age of buyers of housing manufactured with modular technology? According to the results obtained young people (aged up to 35) choose modular apartments relatively more often than people over this age. Taking into account ecological

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trends and the need to use pro-ecological components and materials in construction, it can be assumed that the interest in modular housing might be related to ecological trends prevailing among society. According to respondents, most relevant advantages of this type of technology is that it allows for saving time and construction costs. What is more, modular apartments allow the flexible housing needs of society to be met more quickly. The research results can be used in the policy of planning and shaping housing in Poland, in the development of entrepreneurship, as well as by people associated with the real estate market. The first of them are developers and producers of modular housing, who can use the results as a source of information for planning subsequent projects. Thus, the study indicates the interest in modular apartments and informs sellers about the key factors that guide consumers when making purchasing decisions. Moreover, using the research conducted, real estate agents can better understand modular technology and offer it to consumers more often. The last group are those interested in buying - they can obtain information about alternative technology to traditional construction. Moreover, results indicate the changing reality of residential market and find out what advantages and disadvantages the modular technology has. This may influence the choice of the best way to meet housing needs and aspirations.

Keywords: *the property market, housing, modular property.*

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Classification: R31, R39, A13, E22, D12.

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