Formation of a highly efficient wooden housing construction sector in Russia

O A Bezrukikh

1Irkutsk National Research Technical University, 83, Lermontov st., Irkutsk, 664074, Russia

E-mail: olga.bezrukikh11@gmail.com

Abstract. The Russian government sets global strategic goals for increasing the volume of housing construction - mass multi-storey, multi-apartment and residential housing, creating a comfortable urban environment, comprehensive development of rural areas, construction of social infrastructure facilities in small towns and villages of the country, designated in the national projects “Health”, “Culture” and “Education”. The state assigns a key role in their implementation to modern wooden construction. Recently, many interesting projects have appeared in the field of wooden housing construction. There is a noticeable interest of the state in the development of this area, which is primarily due to the focus on the efficient use of the country's forest resources, as well as the fact that wooden housing construction, due to the high degree of factory readiness of building elements and structures, creates products with high added value and the most transparent from the point of view of taxation, when compared with other areas in construction. Despite this, the potential of wooden construction is not fully disclosed, which does not allow to ensure their environmental friendliness, comfort and energy efficiency. The purpose of the article is to achieve high rates of individual housing construction through a combination of measures aimed at increasing its liquidity. The article analyzes the market of wooden housing construction in Russia, which allowed us to determine the promising construction technologies of the housing construction sector under consideration. The main properties of wood, its advantages and disadvantages are considered. It is determined that the development of industrial housing construction of individual residential buildings will allow not only to implement the tasks of national projects in Russia, but also increase the flow of investment in the construction of individual residential buildings using the industrial method, which will support enterprises that produce factory-made house sets. Based on this, the article contains recommendations for improving the quality of wooden construction products at all stages of the construction life cycle, the implementation of which will generate demand for wooden housing construction, ensuring the rational use of wood and high quality for consumers of products.

The RF occupies a leading position in terms of the state's availability of forest resources. Historically, in Russia, which owns a fifth of the world's forest resources and is the largest supplier of wood to the world market, wood was the most popular building material, and the traditions of wooden architecture are the strongest and most original [1]. However, in recent years, the pace of development of the wooden housing market has been hindered by a technological lag and a clear lack of offers caused by the loss of traditions, the destruction of the wooden housing industry during the years of perestroika, and the switch to the most profitable export of roundwood and wood.
It is legitimate to say that in modern conditions, the forest resource potential of the RF is a real and reliable basis for the full development and functioning of the wooden housing industry. The Ministry of industry and trade of Russia has identified the development of the use of wood in construction as one of the main priorities in the strategy for the development of the forest complex until 2030. Moreover, the implementation of the priority national project “Affordable and comfortable housing for Russian citizens” is impossible without the development of large-scale wooden low-rise housing construction [2]. This type of housing is traditional and most affordable for the majority of the country’s population. What comes to the fore is that wood is a strong, light, environmentally friendly renewable source of raw materials with minimal energy costs for the production of building materials and products. When deep processing of wood into elements of building structures and their disposal causes minimal damage to the environment, that is, wooden building structures have properties that meet the concept of “green construction”. The obvious positive characteristics of wooden housing construction allow this technology to gain popularity lost in Soviet times. At the same time, there are a number of problematic areas that do not allow for mass-scale wooden construction. In this regard, scientific research that ensures the strategic development of competitive production of economically affordable wooden houses is relevant.

In Russia, according to Rosstat, in 2019, the share of wooden housing construction in the total commissioning of low-rise buildings increased from 34% in 2018 to 37% in 2019, and the share of low-rise housing construction in the total volume of housing construction increased by 5% and amounted to 49.1% in 2019 (figure 1).

![Figure 1. Wooden housing construction in the total volume of housing construction.](image)

According to leading companies, since the beginning of the coronavirus epidemic, there has been a sharp increase in requests for the construction of wooden houses in Russia. The number of applications for the construction of wooden houses in March-April 2020 increased by 30% compared to the same period last year. Within six months, the total volume of production, construction and sales of such housing increased by 10-15% [3]. Indicators increased due to the implementation of deferred demand, which was spurred by the instability of the ruble and the conditions of self-isolation, during which many Russians showed a desire to have suburban housing.

World experience shows that wooden house construction is one of the most environmentally friendly and low-cost technologies for building houses. In North America, Scandinavia, some European countries and Japan, the share of wooden housing construction is quite high. So in the USA, Finland,
and Canada, the share of wooden houses in the total volume of low-rise construction is more than 80%. In Japan, this figure is 45%. Russia is not yet among the leaders in the use of wood in construction. Meanwhile, there is a direction that Russia can be truly proud of. In 2019, stadiums were built in Krasnoyarsk and in early 2020 in Irkutsk with the world's largest large-span arches made of GWS. Wooden structures with a span of 99.9 m are the basis of the dome roof. The arches of the ice arenas “Yenisei” and “Baikal” were designed by the laboratory of wooden structures of CRIBS after Kucherenko, manufactured at Nizhny Novgorod WP 78, their installation involved a number of leading construction companies in the country.

The results of the first decades of development of wooden housing construction in market conditions allow us to speak about the revival of a real typology of wooden houses in demand by consumers, taking into account Russian traditions and world experience in creating attractive and comfortable residential buildings, and about the great prospects and opportunities of domestic wooden housing construction, aimed at meeting the ever-growing demand for modern homes.

Today, there is a change in priority in low-rise housing construction – from state tasks for the production of standard wooden residential buildings to meet consumer demand for individual wooden houses, which marked the beginning of fragmentation of the low-rise housing market. This allowed us to develop three main segments of the low-rise housing market:

- elite houses - built at the expense of wealthy buyers according to their preferences, the total area (up to 300 m²) and the size of the building site (not less than 0.5 ha) [4];
- affordable homes - built on borrowed funds with the right to choose the project, with a total area of 150-180 m², with a land plot of up to 0.2-0.3 ha;
- social homes - provided to certain categories of citizens (the poor, the disabled, etc.) on the terms of social employment and built on budget funds for standard reusable projects, the area is determined by minimum social standards (no more than 18 m² per person).

For the development of each segment of wooden house construction, an important direction is to improve technologies that will contribute to the accelerated growth of the wooden house construction industry and the country's timber industry. For the construction of wooden residential buildings in Russia, four technologies of wooden housing construction are in demand - frame and panel technology from open and/or closed elements, modular housing construction and construction from timber or logs. Today, the main structural materials made of wood in the construction of private homes and multi-storey buildings are LVL-beams, glued beams and OSB-panels. At the same time, the technology of wooden housing construction must fully meet the demand, in order to quickly and efficiently meet the needs of consumers. This contributed to the development and application of flexible technologies for wooden housing construction. The specificity of such technologies is the production of ready-made house kits for different types of wooden log-and-cobblestone low-rise buildings, as well as sets of wooden products and parts for houses with walls made of other materials [5].

A wide range of properties of different types of wood ensure not only the development of construction technologies, but also the priority of using wood in many areas of construction, as well as in other industries, such as furniture manufacturing, ship, machine and aircraft construction, etc. This is due not only to the availability of natural resources of this material, but also to the correspondence of its properties to the functional purpose of the products made from it.

As shown in the diagram, tree-based products can be multi-faceted. Modern technologies in construction take into account all types of construction wood that are used in all elements of a residential building (figure 2) [6].
Figure 2. Application of wood products [6].

The demand for wood and its inclusion in the top ten of the world's strategic materials, along with metals, cement and other vital building materials, is due to the presence of positive characteristics:

Low bulk weight with relatively high strength. Construction wood (pine, spruce) weighs about 5 times less than reinforced concrete and 16 times less than steel. The calculated resistance to its axial compression (130 kg/cm$^2$) is the same as that of reinforced concrete (with a concrete grade of 300), and 16 times less than that of steel grade St.3, that is, as much less as wood is lighter than steel [7].

Ease of extraction and ease of processing and production. For many regions of Russia, wood is a local building material that is supplied for construction with minimal time and energy spent on harvesting and delivery. The ability to assemble, disassemble, transfer and alter individual wooden structures and entire structures.

Wood has high thermal insulation properties, due to the low thermal conductivity of wood. A building made of a round log with a diameter of 20 cm is better insulated than a building with brick walls 32 cm thick, lined on both sides with a 1.5 cm layer of plaster [8].

Construction wood has a high durability under proper operation of the structure. As an example of the durability of wooden structures, we can cite the manege covering trusses in Moscow, built in 1817, and the covering trusses of the Column hall of the House of Unions, built in 1819 and restored after a fire in 1857.

Sustainability and renewability of resources. First, due to constant renewal, the damage from deforestation to the environment is minimal. Secondly, the processing process is waste-free, sawdust and shavings are processed to create construction and finishing materials. In addition, wood itself is a natural product and even after processing does not cause any damage to the environment.

The ability of wood to seal. This allows you to get parts and structures not only of large cross-section and length, but also of high strength – production of glued wooden parts (floor bars, Windows and doors, beams and beams for buildings and structures), glued furniture boards and large-span building structures. Technologies for manufacturing glued parts and structures have opened up new opportunities in the construction of multi-storey buildings, including residential buildings up to 17 stories high [9].

Reduced labor and energy costs. The price of a wooden house is almost a quarter lower than the cost of a brick building of the same number of floors and total area. In addition, the use of waste obtained during wood processing both for obtaining other products (slabs, blocks, etc.) and for burning them in order to provide heat energy for production (in particular, for drying lumber) can reduce the overall costs of woodworking industries.

Wood is becoming the main trend in construction, making a significant contribution to the development of modern architecture. However, it should be taken into account that wood is a living
material, so untreated wood usually has the following negative features, which does not allow it to compete with other building materials:

Humidity. Instability to humidity is the most dangerous factor that exposes a wooden product to damage [10]. This problem is solved by high-quality wood, which is selected for construction and special impregnations that will eliminate the negative consequences.

High fire safety. When building a house, it is very important to correctly calculate the location of fire protection systems, as well as to treat the tree with a special fire protection impregnation.

Bark beetles and wood rot. The solution to the problem can be achieved through modern means for wood processing. In this case, it is important to use both initially high-quality raw materials and processing tools.

In the process of technology development, all the listed negative properties of wood as a building material can be minimized, which will allow you to focus exclusively on positive characteristics, ensuring attractiveness and demand for construction purposes. The available reserves of wood in most regions of Russia, the price and quality advantages of wooden houses over houses made of other building materials determine the lack of alternatives to this type of housing construction for the implementation of national tasks in the field of providing the population with high-quality, affordable and energy-efficient housing.

It is possible to achieve high rates of wooden housing construction through a combination of measures aimed at increasing its liquidity. First of all, it is necessary to ensure the formation of a new segment - complex low-rise buildings using the industrial method with the involvement of specialized contractors and manufacturers of modern materials and house kits. For the purposes of complex individual housing construction, it is advisable to use a low-rise model, which involves combining different types of low-rise buildings on the same territory: individual and blocked houses, apartment buildings up to 4 floors high. Mixed development will ensure a smooth transition between low-and medium-rise models [11]. To stimulate the development of wooden housing construction, it is necessary to develop a set of measures to support organizations engaged in the production of factory-made sets of houses. In turn, home kit manufacturers must also ensure high quality and availability of finished products. Based on this, it is advisable to take a number of measures aimed at ensuring the competitive stability of wood at all stages of the life cycle of the house (figure 3).

The cycle of existence of a house includes the stages of design, manufacture of a house kit, construction, and operation of the house. At each stage, the properties and characteristics of wood must be taken into account and the required quality of the final construction product must be ensured. This will ensure high quality of all stages of creation and existence of wooden houses by designers and manufacturers [12]. There is no denying that the state plays a decisive role in the process of quality control of construction products. In 2020, three new SR were developed in Russia up to this time, the industry in this direction had only one SR, which was not adapted to the russian reality. New SR “Residential and public buildings with wooden frames. Rules for design and construction” will have a wider application, both in relation to various frame technologies, and by building types, including for apartment buildings and public buildings [13,14]. SR “Buildings and structures made of glued wooden beams. Rules for the design and construction of” and SR “Residential and public buildings of log construction. Rules of design and construction” will become absolutely new for Russia, they will help to set quality standards in construction, thus, there will be guidelines for both buyers and manufacturers and builders of wooden housing construction. These changes confirm the interest of the government and scientific organizations in developing wooden housing construction and increasing the use of wood in construction [15].
**Designing**

- the first and key stage, which determines the basis of rational use of wood:
  - taking into account the functional purpose of each wooden structure and detail, its correlation with the properties and features of a particular wood species;
  - use of saw products with an optimal cross-section, which will reduce the costs of sawmilling and the entire house-building industry;
  - application of glued parts and the possibility of using raw materials from soft-leaved wood for their production;
  - the determination of the necessary storage conditions of the parts on the subsequent stages of existence of the house and measures for their protection (impregnation, finishing, etc.);
  - account in the design documentation for guidance and instructions for contractors for the next stages - technology manufacturing components and structures, installation of the building and its finishing care (repairs, inspections, etc.) at home during the period of its operation and to determine (in the format of a passport) security guarantees of a wooden house, rules, duties and responsibilities of all participants in its creation and maintenance.

**Production**

- the second stage, at which the organization and technological operations of woodworking production ensure the implementation of design solutions:
  - implementation of systems of measures for the rational use of wood raw materials - from the moment of its receipt for processing to completion and storage (in certain temperature and humidity conditions) of finished structures and parts. The system of measures should include:
  - implementation of a complex control operations at all stages of production - from receipt of raw wood to the paperwork on the finished housing complex; what plans control for each stage of production, which prepares the technologist and maintains its head - it underlines the role and responsibility of the first persons of the enterprise the system of quality assurance of products.

**Construction**

- the final stage of creating a house should be carried out according to the work organization plan created by the work producer in agreement with the designer.
  - compliance with the storage conditions for building kits on the construction site;
  - maintaining the order and quality of installation of house structures, step-by-step control (foundation construction, wall construction, floor construction, etc.) and author's supervision of the project developer.

**Operation**

- it checks not only the quality of the previous stages of building a house, but also determines the real durability (this is an indicator of the competitive stability of wood in housing construction) of its existence. It is not only the quality of the project, home kit, and construction that can be crucial, but also the quality of home maintenance.

**Figure 3.** Measures to ensure the competitiveness of wood at all stages of the life cycle of the house.

Today, the market of wooden house construction is at the stage of growth, during which it is necessary to choose the optimal and effective directions for the development of wooden house construction in the RF:
- the construction of agricultural buildings: barns, warehouses of fertilizers and other, including areas with aggressive environment;
- construction of health care facilities (paramedic and midwifery centers, hospitals), police strongholds, forester's offices combined with housing, etc.; here the main advantages will be the cost and speed of turnkey construction, the possibility of implementing projects in remote areas;
participation of wooden housing construction enterprises in state programs for relocation from dilapidated and dilapidated housing, prompt provision of housing to areas affected by natural disasters, provision of housing to privileged categories of citizens;
road infrastructure: bridges and pedestrian crossings;
recreational facilities that give an impetus to the development of tourism: hotels, resorts, holiday homes, motels, etc.

The above-mentioned directions support the state policy strategy – integrated development of territories, which is unthinkable without mass low-rise housing construction in different regions of Russia. Territorial development of the country and improving the quality of life of its citizens — the basis of formation of demand for modern low-rise housing stock from the typological diversity of wooden houses when the principles and conditions of “green building” defining environmental security and energy independence as the house and the local area.

References
[1] Generalova E M and Karpova A M 2018 “Green” technologies for solving the problems of modern cities Traditions and innovations in construction and architecture. Architecture and design: a collection of articles pp 46-51
[2] Shchegoleva E V 2017 Ecological construction using wood as the main building material Scientific Bulletin of the Voronezh state University of architecture and civil engineering. Series: Innovations in construction pp 142-149
[3] Korenevskaya M A 2017 Prospects for construction of wooden buildings and structures for public and business purposes in the Leningrad region StudArctic Forum 5(5) pp 37-46
[4] Kozlovskaya M, Strukova Z and Kaleja P 2015 Methodology of cost parameter estimation for modern methods of construction based on wood Procedia Engineering 108 pp 387-393
[5] Asdrubali F and Ferracuti B 2017 Building and Environment 114 pp 307-332
[6] Marchesi M and Ferrarato I A 2015 Addressing the adaptive customization of timber prefabricated housing through axiomatic design Procedia CIRP 34 pp 199-205
[7] Lavoie P 2008 Green building trends are advancing wood as a building material Wood Market Trends in Europe 49 pp 9-12
[8] Jonsson H 2018 Production Strategy in project based production within a house-building context Studies in Science and Technology 1892
[9] Figueira G, Amorim P, Guimarães L, Amorim-Lopes M, Neves-Moreira F and Almada-Lobo B 2015 A decision support system for the operational production planning and scheduling of an integrated pulp and paper mill Comput. Chem. Eng. 77 pp 85–104
[10] Sturgill B and Giedeman D C 2016 Factor shares, economic growth, and the industrial revolution In Essays in Economic and Business History 34(1) pp 165–207
[11] Zimmer A T 2017 People Planet and Profit: Unintended Consequences of Legacy Building Materials. In Journal of Environmental Management 204 pp 472–485
[12] Tyuryukhanov K Yu and Pugin K G 2019 Impact of the surface of particles of moulding sand on the structural formation of asphalt concrete Proceedings of Universities. Investment. Construction. Real estate 9(3) pp 566–577
[13] Dobruskina M A, Petrov A V and Bat-Erdene Z 2019 Improving the technology of retaining walls in the Irukts region using gabion baskets Proceedings of Universities. Investment. Construction. Real estate 9 (2) pp 312–323
[14] Gorbachevskaya E Y et al 2020 IOP Conf. Ser.: Mater. Sci. Eng. 880 012031
[15] Yaskova N Yu and Sarchenko V I 2018 Development of strategic approaches to the creation of aqua-territorial industrial complexes in the Arctic zone Proceedings of Universities. Investment. Construction. Real estate 8 pp. 84-93 DOI: 10.21285/2227-2917-2018-2-84-93