Possibilities of using wood and wood materials in the construction of the Republic of Karelia

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Abstract. The timber industry complex in the Republic of Karelia is one of the leading industrial complexes in the region. In modern conditions, the timber industry of the republic is experiencing difficulties due to export restrictions on the exportation of manufactured products. The purpose of this study is to assess the potential of the timber industry of the Republic of Karelia and identify the possibilities of using wood and wood materials in construction in the republic and in neighbouring regions of the North-West of the Russian Federation. The data of the Federal State Statistics Service and the Ministry of Natural Resources and Ecology of the Republic of Karelia were used as the main sources of empirical indicators. The methods of economic and mathematical modelling, retrospective and statistical analysis are used as research methods in the article. Based on the results of the analysis, the main directions of wood use in construction in the territory under consideration and in the territory of neighbouring regions are determined. Special attention is paid to the development of enterprises of deep processing of wood and the use of products of a high degree of factory readiness in construction.

1 Introduction

The North-Western Federal District is considered as one of the most promising for the development of the timber industry and wooden housing construction along with the Central and Siberian Federal Districts. The factors determining the prospects of the territory are:
- More than 17 percent of the estimated Russian logging area is concentrated in the North-Western Federal District;
- The forest complex of the territory is represented by a full range of productions;
- Territories provide the largest share of non-tax revenues from the use of forests;
- There are a sufficient number of very large companies operating in the territories.

As part of the implementation of strategic measures in the North-Western Federal District, it is planned to expand production in almost all segments: in logging and lumber production, pulp and paper industry, production of wood boards and plywood, wooden house construction and production of pellets. It is economically attractive to consider an

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increase in capacity as part of the expansion of existing and (or) the creation of new timber processing clusters. Taking into account the measures of state support, the North-Western Federal District is considered as attractive for investment in new projects for the production of lumber.

The timber industry in the Republic of Karelia is one of the leading, and its share in industrial production is 30.5%. In modern conditions, the timber industry of the republic is experiencing difficulties due to export restrictions on the exportation of manufactured products. In 2021, the export of wood decreased to 8.1% of the total volume of harvesting.

To date, there have been problems with the sale of both raw materials and processed products of the timber industry. At the same time, the strategy for the development of the Karelian forest complex until 2030, during its development and approval, did not provide a crisis plan for such a situation.

The purpose of this study is to assess the potential of the timber industry of the Republic of Karelia and identify the possibilities of using wood and wood materials in construction in the republic and in neighboring regions of the North-West of the Russian Federation.

The issues of wood and wood materials used in construction and deep processing of wood have been reflected in the works of foreign and Russian scientists. In the works [1, 2, 3, 4, 5], the issues of the use of wood in multi-storey construction are considered. Studies [6, 7, 8, 9, 10] are devoted to the use of wood in the construction of green buildings. Separate studies [11, 12, 13] are devoted to the use of wood in the construction of individual low-rise houses. Scientists also touch upon the use of wood in construction as a structural material [14, 15, 16, 17, 18, 19, 20] and the features of wood as an environmentally friendly and renewable resource [21, 22, 23].

2 Materials and Methods

The territory of the Republic of Karelia, which is one of the six territories included in the northern economic region of the Russian Federation, was chosen as the object of this study. Part of the territory of the republic (38%) is included in the Arctic zone of the Russian Federation.

The annual volume of timber harvesting in the Republic of Karelia is 7.5 - 8 million cubic meters, and the estimated cutting area is represented in the amount of 12.4 million cubic meters. The total area of forests is 14.9 million hectares, and the total area of forest lands is 14.5 million hectares. The territories covered by forest vegetation amount to 9.3 million hectares, including:

- With a predominance of softwoods: 8.12 million hectares (87%);
- With a predominance of hardwoods: 1.16 million hectares (13%).

The data of the Federal State Statistics Service and the Ministry of Natural Resources and Ecology of the Republic of Karelia were used as the main sources of empirical indicators. The methods of economic and mathematical modeling, retrospective and statistical analysis are used as research methods in the article.

3 Results and Discussion

3.1 Assessment of the potential of the timber industry complex

More than 200 organizations, including 57 forest plots tenants, are engaged in harvesting in the Republic of Karelia. The main suppliers of raw materials for woodworking are the companies of JSC "LHK "Kareellesprom", LLC "Russian Forest Alliance", LLC "Karlis-Prom" and CJSC "Nord Inter House".
In recent years, there have been positive growth rates in the production of lumber. In 2022, the production index for this type of activity amounted to 81.2%, which in value terms is 20.4 billion rubles (compared to 2021, this indicator increased by 57.7%). According to statistics, 879.4 thousand cubic meters in 2022 amounted to the volume of lumber production, which is 74.2% more than in 2021. From the consideration of Table 1, it follows that the production of lumber has a positive growth rate of 29% compared to 2017.

Table 1. Production in the Republic of Karelia in kind.

<table>
<thead>
<tr>
<th>Name of types of products</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumber, thousand cubic meters</td>
<td>896.1</td>
<td>923.3</td>
<td>1068</td>
<td>1119</td>
<td>1158</td>
</tr>
</tbody>
</table>

Among the largest enterprises engaged in the production of lumber from wood on the territory of the republic, the following companies can be distinguished, which are producers of 90% of high-quality softwood lumber (spruce, pine):
- 7 large sawmills - produce more than 1 million cubic meters of lumber:
  LLC "Solomenskiy LZ" (Pryazhinsky district, Chalna settlement);
  LLC "Settles" (Pitkyarantsky district, Impilakhti settlement);
  LLC "Karelian Wood Company" (Kostomuksha);
  LLC "Karlis-Prom" (Sortavala, village. Vyartsilya);
  LLC "Promles" (Prionezhsky district, Shuiskaya station);
  LLC "Sortavalsky LZ" (Sortavala, Rautakangas settlement);
  LLC "KLEZ-Astar" (Kondopoga).
- 2 plants for the production of plates - produce up to 450 thousand cubic meters of plates:
  LLC "DOK Kalevala" (Petrozavodsk) - OSB-plates;
  LLC "DOK Pindushi" (Medvezhegorsky district, village. Pindushi) - chipboard slabs.
- 1 veneer production plant – produces up to 40 thousand cubic meters of products:
  LLC "Karelian Plywood" (Lahdenpohya).

Production capacities for these types of products are used at a level exceeding the average level (Table 2).

Table 2. Availability and use of production facilities.

<table>
<thead>
<tr>
<th>Name of types of products</th>
<th>Average annual capacity operating in 2020</th>
<th>Average annual capacity utilization, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2017</td>
<td>2018</td>
</tr>
<tr>
<td>Lumber, thousand cubic meters</td>
<td>1187.1</td>
<td>66.1</td>
</tr>
</tbody>
</table>

The main characteristics of enterprises for the production of slab wood materials are presented in Table 3.

Table 3. Main characteristics of enterprises for the production of slab wood materials.

<table>
<thead>
<tr>
<th>Manufacturer's name</th>
<th>Type of products</th>
<th>Output volume</th>
<th>Location of production</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLC &quot;DOK Kalevala&quot;</td>
<td>OSB plates</td>
<td>300 thousand cubic meters</td>
<td>Petrozavodsk</td>
</tr>
<tr>
<td>LLC &quot;DOK Pindushi&quot;</td>
<td>Chipboard plates</td>
<td>up to 100 thousand cubic meters</td>
<td>Medvezhegorsky district, village.</td>
</tr>
</tbody>
</table>
According to statistics, in 2022, the volume of production of plate products amounted to 423.7 thousand conventional cubic meters, which is 5.2% more than the volume of production in 2021.

At the same time, the production of ready-made building structures, house kits and modular buildings made of wood is actively developing on the territory of the republic (Table 4).

Table 4. Production volumes of a high degree of factory readiness products for the period 2021-2022.

<table>
<thead>
<tr>
<th>Type of products</th>
<th>2021</th>
<th>2022</th>
<th>Growth rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefabricated wooden construction structures, million rubles.</td>
<td>348.7</td>
<td>423.6</td>
<td>121.5</td>
</tr>
<tr>
<td>Factory-made wooden houses, thousand sq. m</td>
<td>2.8</td>
<td>18.2</td>
<td>650</td>
</tr>
<tr>
<td>Garden houses and buildings, pcs.</td>
<td>260</td>
<td>259</td>
<td>99.6</td>
</tr>
</tbody>
</table>

From the consideration of Table 4, it can be seen that the highest growth rates are observed in the production of factory-made wooden houses (the volume of their manufacture in 2022 increased 6.5 times compared to the previous year). This fact can be explained by the stable growth of the share of individual residential construction on the territory of the republic and its dominant presence in the total commissioning of housing in the amount of 61.8% [24, 25]. The main companies and their products are presented in Table 5.

Table 5. The main manufacturers of products with a high degree of factory readiness.

<table>
<thead>
<tr>
<th>Manufacturer's name</th>
<th>Type of manufactured products</th>
<th>Location of production</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLC &quot;Cozy House&quot; (Brand &quot;Karelian profile&quot;)</td>
<td>Frame house kits and rafter structures</td>
<td>Prionezhsky district, Shuya settlement</td>
</tr>
<tr>
<td>LLC &quot;Goakhte&quot;</td>
<td>Frame-panel house kits</td>
<td>Prionezhsky district, the village of Verkhovye</td>
</tr>
<tr>
<td>LLC &quot;Nodverk&quot;</td>
<td>Houses made of CLT panels, glued beams</td>
<td>Sortavala</td>
</tr>
<tr>
<td>LLC &quot;KarelBani&quot;</td>
<td>Ready-made baths and cabins</td>
<td>Petrozavodsk</td>
</tr>
<tr>
<td>LLC &quot;Linna&quot; (Brand &quot;ECO-TALO&quot;)</td>
<td>Ready-made house kits of frame houses according to Finnish construction technology</td>
<td>Petrozavodsk</td>
</tr>
<tr>
<td>LLC &quot;Amperia&quot;</td>
<td>Construction of frame houses</td>
<td>Petrozavodsk</td>
</tr>
<tr>
<td>LLC &quot;Northern Architect of Karelia&quot;</td>
<td>Log cabins of wooden houses and baths from Karelian pine</td>
<td>Prionezhsky district, Chalna settlement</td>
</tr>
<tr>
<td>LLC &quot;Tarya&quot;</td>
<td>Construction of frame houses</td>
<td>Petrozavodsk</td>
</tr>
<tr>
<td>Individual entrepreneur Kalitin Roman Sergeevich</td>
<td>Construction of frame houses</td>
<td>Prionezhsky district, Chalna settlement</td>
</tr>
</tbody>
</table>
Figure 1 shows the distribution of the considered woodworking industries on the territory of the Republic of Karelia. As can be seen from the figure, a greater number of enterprises are concentrated in the south of the territory. There are significantly fewer woodworking enterprises in the territories classified as the Arctic zone of the Russian Federation.

Based on the analysis performed, it can be concluded that the territorial timber industry complex of the Republic of Karelia has sufficient potential to ensure construction in the region. However, the distribution of woodworking enterprises across the region is uneven. In the northern territories of the republic, woodworking enterprises are represented in insignificant numbers.
3.2 Possibilities of using wood and wood materials in construction

The use of wood and wood materials on the territory of the Republic of Karelia is caused by the following factors:

- Export restrictions on the export of wood abroad and, as a result, the need for processing of wood in the Russian territory;
- More than 60% of the input of residential space in the Republic of Karelia is provided by individual housing construction projects and about 30-50% of individual housing construction projects are implemented in wooden structures;
- The need to use in the construction of a high degree of factory readiness products (structures and products) and, as a consequence, the need to introduce deep processing technologies to obtain such products;
- The market niche of modular wooden housing construction of capital buildings and industrial production of modules of a high degree of factory readiness is practically not occupied either in the Republic of Karelia or in the Russian Federation.

The following are considered as the main directions of using wood and wood materials in construction:

- The use of wood and wood materials in the production of house kits and modular buildings of a high degree of factory readiness;
- The use of solid treated wood as a structural material of load-bearing structures;
- The use of solid treated wood as a material for finishing layers;
- The use of glued wood as a structural material of supporting structures;
- The use of crushed wood and woodworking waste for the production of thermal insulation and plate building materials.

One of the promising areas of intensification of the use of wood is the development of wooden house construction. Its development is due to a number of additional factors – wooden house construction is paid close attention by both federal government bodies and the governing bodies of the constituent entities of the Russian Federation, the Ministry of Industry and Trade of the Russian Federation positions wooden house construction as a tool for the development of the Russian timber industry.

According to the Strategy for the development of the forest complex of the Russian Federation until 2030, one of the main directions of development of the industry is considered wooden house construction, focused, among other things, on the domestic market. The target vision in the field of the forest industry provides for the provision of deep processing of wood on the basis of the construction of new and expansion of existing wood processing enterprises, as well as the production of wooden house construction products. Separately, it is possible to note the competitive advantages of wooden low-rise residential buildings in comparison with other types of residential buildings: low cost, simplicity and speed of construction, less burden on the environment, the possibility of almost complete disposal at the end of the service life. According to the provisions of the Strategy, the main factors constraining the development of wooden housing construction in Russia are: outdated regulations, restrictions on obtaining credit resources, lack of state support and a large share of the unskilled services market (a large percentage of low-quality and unsafe products).

The developers of the draft Strategy for the Development of the Construction industry of the Russian Federation until 2030 identify an insufficient share of industrial housing construction (production of house kits and individual modules) as one of the main problems in the field of housing construction in Russia. Certain provisions of the draft Strategy focus on the need to support the production of modern house kits in terms of expanding the practice of wooden individual and low-rise housing construction in the segments of housing construction and the construction of socio-cultural infrastructure. Attention is also focused on creating conditions for long-term demand for the products of renovated enterprises (the
possibility of participating in renovation programs, replacement programs for dilapidated and dilapidated housing, housing construction for certain categories of the population). Industrial production of house kits, allows you to reduce the price of a finished house for the consumer, reduce the construction time while improving the quality of housing.

One of the main factors in improving the mechanisms for the construction of social infrastructure is the need to increase the economic efficiency of the construction of infrastructure facilities in terms of technology development and the creation of production facilities for the construction of prefabricated low-rise wooden buildings with a high level of factory readiness. The Government of the Russian Federation also encourages wooden housing construction using modern technologies in the regions when constructing social facilities - kindergartens, sports and recreation complexes, paramedic and obstetric stations, as well as housing to replace dilapidated and emergency.

In accordance with the provisions of the Strategy for the Development of the Forest Complex of the Republic of Karelia until 2030, the promotion of the development of wooden housing construction in the region is allocated to a separate group of activities. The provisions of the strategy note that, despite the low quality of the housing stock in the settlements, there is no program for the development of wooden housing construction in the Republic of Karelia. As opportunities in the development of the forest complex, the creation of comfortable living conditions in forest settlements with the development of social and household infrastructure based on wooden housing construction, as well as the development of areas of activity working for the economy of forest settlements, including in the field of wooden housing construction, is noted. As the main development activities, the strategy provides:

- Carrying out a full accounting of the availability and condition of housing stock, educational facilities, healthcare, trade, etc., both in cities and in numerous settlements;
- Development of a unified program for the development of wooden housing construction, taking into account the settlement of dilapidated and dilapidated housing, the construction of social housing;
- Taking measures to popularize and develop the wooden house construction market at different levels of government (reduction of the loan rate for buyers of wooden houses due to state subsidies, introduction of quotas for the use of wooden house construction materials in regional housing construction programs, application of benefits in mortgage lending when buying apartments in wooden houses);
- Development of ecological tourism, including in winter.

In 2020, the Government of the region began to develop a number of measures to support wooden housing construction. Work is underway to adjust regulatory documents in order to develop state support measures for enterprises engaged in the production of houses and house kits made of wood on the territory of Karelia. The Republican authorities also expect a positive reaction from the banking community in terms of mortgage lending to the population for the construction of wooden houses. In the Strategy of development of the forest complex of the Republic of Karelia at the moment, two main types of houses are distinguished on the modern market: from solid wood (chopped, timber, houses made of rounded logs and glued beams) and panel-frame houses.

Representatives of the business community note in 2020 an increased interest among the population in the construction of country houses. Real estate agencies and developers of Karelia in the spring of 2020 noted an increase in demand in the suburban real estate market. During the period of self-isolation and quarantine measures, many residents of apartment buildings thought about purchasing or building an individual residential building that allows them to experience the conditions of pandemics more comfortably. Construction companies engaged in the construction of wooden residential buildings also distinguish two of the most popular types of buildings according to the technology of their construction:
frame, log and timber. At the same time, it is worth noting that frame wooden buildings are gaining more and more popularity.

As mentioned above, two main technologies for the construction of low-rise wooden buildings are strategically distinguished: frame and with the use of solid wood elements. In the suburban real estate and construction market in the spring of 2020, there was an increase in demand in similar market segments. When analyzing the market in 2022, in addition to the two mentioned technologies for the construction of wooden buildings, two more promising types of buildings were identified – panel buildings based on CLT wood structures and modular buildings of a high degree of factory readiness based on frame technology (Figure 2).

Another promising direction of using wood in the construction, reconstruction and overhaul of buildings can be considered the mass use of factory-made structures. Examples of such structures can be trusses and beams on metal-toothed plates, as well as glued wooden structures.

The production of slab materials in the region also has prospects for development. Three enterprises for the production of the following slab materials are successfully operating on the territory of the republic: OSB-plates, chipboard plates and plywood. A promising direction is the organization of the production of windproof panels based on wood fiber for frame housing construction. There are no manufacturers of this material on the domestic market. The main similar materials used in the construction of frame buildings are Isoplaat plates and Baltermo plates, which are manufactured abroad.

The use of chipboard also has prospects for use in construction, for example, as bases and dry screeds in floor structures. In Russia, products under the Quick Deck brand are presented, which are moisture-resistant tongue-and-groove building slabs.

A promising direction is also the production of elements of permanent formwork of their chip-cement slabs similar to those used in Velox technology. This technology has a number of advantages - economical consumption of building materials, fast construction rates, strength, durability, environmental friendliness, resource saving (heating costs are 40% lower), simple installation technology.

A separate direction is the use of crushed wood and woodworking waste in the production of building materials. Examples of such productions are the manufacture of fixed formwork elements from wood-cement composite (similar to Durisol technology). The elements of Durisol permanent formwork consist of 90% coniferous wood chips bonded with Portland cement. Coniferous wood chips can be considered as a secondary raw material obtained from the waste products of Karelian lumber manufacturers.

The traditional direction of using wood in construction is the production of materials for interior and exterior decoration of buildings. Such materials include the following: clapboard, plank, block house, wood panels, parquet board, piece parquet, imitation timber and decking.
Fig. 2. Classification of wooden buildings using wood as the main material of supporting structures.

4 Conclusions

Summing up the results of the performed analysis, the following results can be distinguished. The factors that determine the use of wood and wood materials on the territory of the Republic of Karelia include the following:

- Export restrictions on the export of wood abroad and, as a result, the need for processing of wood in the Russian territory;
- More than 60% of the commissioned residential area in the Republic of Karelia are objects of individual housing construction and about 30-50% of this area is realized in wooden structures;
- The need to use in the construction of products of a high degree of factory readiness (structures and products);
- The need to introduce technologies for deep processing of wood to obtain products of a high degree of factory readiness;
- The need for the development of modular wooden housing construction of capital buildings and industrial production of modules of a high degree of factory readiness.

As the main directions of using wood and wood materials in construction, the following can be distinguished:
- The use of wood and wood materials in the production of house kits and modular buildings of a high degree of factory readiness;
- The use of solid treated wood as a structural material of load-bearing structures;
- The use of glued wood as a structural material of load-bearing structures;
- The use of whole treated wood as a material for finishing layers;
- The use of crushed wood and woodworking waste for the production of thermal insulation and slab building materials.

Factors hindering the expansion of the use of products of deep processing of wood in construction, the following can be noted:
- Lack of a regulatory framework in the field of wooden housing construction;
- Lack of highly qualified personnel, both in the field of design and construction, and in the field of industrial production of products of a high degree of factory readiness;
- Lack of Russian software in the field of design, calculation and industrial production of building structures and factory-made elements;
- The lack of Russian equipment for the industrial production of building structures and elements of factory-made buildings.

In general, the timber industry of the Republic of Karelia has sufficient potential to ensure the production of building materials and construction products. However, due to export restrictions and reorientation to the domestic market, a separate restructuring of the segments in the field of construction and industrial wood processing is required. Promising areas of reorientation to the domestic consumption market are:
- The developing direction of wooden housing construction, both low-rise and multi-storey buildings. Separately, it is necessary to highlight the development of the production of modular buildings of a high degree of factory readiness and wall panels made of CLT wood;
- Development of factory production of building structures and products made of high-grade lumber and glued wood;
- Expansion of the range of manufactured wood slabs based on crushed wood and woodworking waste.

Further stages of this study consider the following:
- Assessment of the need for the above-mentioned products made of wood and wood materials in the territories of the Republic of Karelia and neighboring regions;
- Assessment of the necessity and possibility of creating new woodworking productions of products of a high degree of factory readiness, especially on the territory of the Arctic zone of the Republic of Karelia.

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