Implementation of the circular economy in the timber industry of the Krasnoyarsk territory

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Abstract. The article is devoted to the issues related to the development of methods for introducing the circular economy to the timber industry in Russia. Much attention is given to the introduction of a closed-loop economy that will create a beneficial environment for the development of the timber industry, and the use of this technique will allow enterprises to solve economic, resource and ecological problems. It is spoken in detail about actions of the development and establishment of the circular economy by the example of the Krasnoyarsk territory taking into account international experience of implementation. The model of the technological process of a closed-loop timber industry has been developed based on the Strategy for Development of Industry for Sorting, Recycling and Treatment of Waste for the period until 2030. The efficiency of the model implementation was analyzed. The findings suggest that this approach could also be useful for the enhancement of economic efficiency at enterprises. It has been found that use of waste-free production can reduce the environmental burden in the Krasnoyarsk territory.

1. Introduction
The circular economy (also known as a closed-loop economy) is an economic system aimed at eliminating waste and the continual use of resources. Circular systems employ reuse, sharing, repair, refurbishment, remanufacturing and recycling to create a closed-loop system, minimising the use of resource inputs and the creation of waste, pollution and carbon emissions. This is what distinguishes this type of economy from other types [1].

The circular economy can be characterized by the concept that is presented in figure 1.

![Figure 1. The concept of the circular economy [1].](image-url)
Many different methods and production technology can make production completely waste-free or at least reduce the amount of waste to a minimum. Principals of modern foreign enterprises have already known that waste is an unused resource. As a result, this indicates management inefficiency. Waste recycling is currently one of the most common ways to increase profits [2].

The EU countries have long adopted a strategic plan for the transition to the circular economy with appropriate state regulation. In this sense, Russia is slightly behind neighbouring countries, perhaps due to its raw material orientation, but some actions in this direction are already underway. For instance, in January 2018, the Government of the Russian Federation adopted the Strategy for Development of Industry for Sorting, Recycling and Treatment of Waste for the period until 2030. However, dynamics in this area is quite slow, given the speed at which natural resources are consumed [3].

2. Relevance

The article of authors [4] analyzed the prospect of implementing a resource-saving, environmentally and economically sound approach for the organization of production. This is a waste-free (or low-waste) production, which is related to the development of global and domestic industrial production. Studying the problems of introducing the circular economy in certain regions of the Russian Federation, it is worth focusing on the timber industry in the Krasnoyarsk territory, where about 4 percent of the world's wood reserves are concentrated, which is about 1599653.4 square meters of woodland. Moreover, forest resource degradation and inefficient management policy of the timber industry enterprises in the Krasnoyarsk territory are major issues. The analysis of the financial viability of the enterprises is presented in table 1 [5].

Table 1. The analysis of the financial viability of the timber industry enterprises in the Krasnoyarsk territory.

| Indicator                                           | “Lesosibirsky LDK №1” JSC | “Boguchansky LPK” LLC | “Krasnoyarskles omaterialy” JSC | “Novoeniseysky lesokhimichesky kompleks” CJSC |
|-----------------------------------------------------|-----------------------------|-----------------------|-------------------------------|---------------------------------------------|
| 1. Financial stability                               | -2                          | -2                    | -2                            | -2                                         |
| 1.1. Financial autonomy ratio                        | -2                          | -2                    | -2                            | -2                                         |
| 1.2. Working capital financed by equity to total assets ratio | -2                          | -2                    | -2                            | -2                                         |
| 1.3. Return on investment ratio                       | -1                          | -1                    | -2                            | 0                                          |
| 2. Paying capacity                                  | -1                          | -2                    | -2                            | -2                                         |
| 2.1. Current ratio                                   | -1                          | -2                    | -2                            | -2                                         |
| 2.2. Quick ratio                                     | -1                          | -2                    | -1                            | -2                                         |
| 2.3. Cash ratio                                      | -1                          | -2                    | -1                            | -2                                         |
| 3. Activity effectiveness                           | -2                          | -2                    | -2                            | -2                                         |
| 3.1. Return on sales                                 | -2                          | -2                    | 1                             | -1                                         |
| 3.2. Net profit margin                               | -2                          | -2                    | -2                            | -2                                         |
| 3.3. Return on assets                                | -2                          | -2                    | -2                            | -2                                         |
| Total score                                          | -1.2                        | -1.9                  | -1.4                          | -1.7                                        |
| The financial condition of the                       | The financial condition of the | The financial condition of the | The financial condition of the              |                                             |
A comparative analysis was made of the main financial indicators of the timber industry enterprises in the Krasnoyarsk territory for 2018 with similar industry average indicators for 2018. The indicators of all organizations engaged in the same activity were taken as the industry average.

To calculate the efficiency ratio of enterprise, the industry average values of indicators were used, which were calculated based on the accounting statements for the period 2018. All data was taken from an official source – the Federal tax service. Enterprises engaged in the production of sawn timber were differentiated according to the amount of assets, the total of which was not less than 10 thousand rubles, and to the revenue exceeding 100 thousand rubles. This was necessary in order to reduce a wide range of enterprises under consideration.

Due to the analysis of headline financial indicators of enterprises, we found out that the financial condition of the timber industry enterprises in the Krasnoyarsk territory is significantly worse than financial condition of half of all large enterprises engaged in the same activity.

The lack of effective raw material usage, given the current level of technology, causes this financial condition. According to statistics, around 50-55 percent of waste remains from the production of finished products that are used as fuel, or, even worse, are deposited in landfills and incinerated there. The principles and procedures established by The Russian Forest Code are violated, and the extensive forest management continues, in fact.

3. Problem statement

Recently, more and more attention has been paid to the development of the timber industry. The authorities understand that due to the current circumstances – depletion of forest resources – it is necessary to take important steps to change the situation. So far, a large number of programs and strategies have been developed in this direction. After having studied that, we have considered that the basic guideline of solving the problem is a deep wood raw materials processing.

Nowadays, the issue of waste processing is one of the most urgent problems for many branches, including the timber industry. The problem covers economic, resource and ecological aspects. Waste is generated at every stage of the sawmilling and woodworking technological process; from the harvesting to the production of the finished products.

The Krasnoyarsk territory also faced this problem. According to analysts, that is associated with outdated methods of wood processing, that is, craft production, and a low level of technological process, which led to a lag behind the leading enterprises of the timber industry in Russia. Calculations indicate that 60 million cubic meters of waste are generated annually from wood processing, 75 percent of which is accounted for by raw waste lumber. These values indicate the irrational use of lumber and the need to apply measures to resolve the situation of recycling. Currently, to determine the direction of further waste usage, size and quality characteristics and economic factors have been introduced. The use of raw waste lumber for the production of products is possible only after chemical and mechanical treatment, but in some cases, the option of using it without any treatment is considered.

The larger sized wood waste, that is raw waste lumber, which can be used directly in the production of various products, is the most significant and valuable. This includes wooden slabs, laths, etc. The range of the application is huge since it is possible to manufacture both small saw products and glued laminated boards, as well as the production of wood-chemical products (pulp, wood alcohol, fodder yeast, etc.).

Waste chips have less value due to the practical applicability, which is to manufacture certain types of products. As a result, the efficiency is not so high in comparison with raw waste lumber. Waste chips
include sawdust, shavings, and bark. The range of applications of waste chips is limited. It is used as a technological raw material for slab and wood-chemical production, as well as for household and industrial purposes. Using this group of waste as fuel or fertilizer is the least time-consuming method.

4. Methods
At present, numerous problems must be addressed. Today's reality can be described as the time of constant depletion of natural resources. However, the foreign and domestic timber industry has accumulated enough experience in the use and processing of wood waste. Among the various technological projects, three main areas involve waste: building materials, fuel, and a source for wood-chemical products.

Let us now analyze the transition to the circular economy in foreign countries. It is most appropriate to consider the timber industry enterprises of Canada and Finland, which are comparable in terms of natural, geographical and climatic conditions with our country.

To prove the effectiveness of a closed-loop model, graphs of revenue changes at some enterprises of the timber industry in these countries are presented using sources [6] and [7]. As can be seen in figure 2, there is an increase in profits, which undoubtedly confirms the economic benefits of directing production waste to the technological process of creating products.

![Figure 2](image-url)

**Figure 2.** A graph of changes in revenue of foreign enterprises of the timber industry in the period from 2016 to 2019.

These countries have been most successful in addressing the issue of transition to a circular economy, adhering to a strategy based on the principles of sustainable forest management and development of the timber industry. As a result, they are clearly successful in rational and efficient forest management, which makes a significant contribution to national economic development.

It should be noted that the transition to the circular economy in these countries was developed after the intervention of state structures and the government. These countries determined the top priority, which was the development of forest policy and programming for the development of industry based on forest resources. Moreover, the focus was on a deep wood raw materials processing and the creation of small enterprises in the timber industry. Further, the state made serious investments, namely, allocated a large share of the federal budget to industry research and development, forestry engineering, and innovations of all subsectors of the timber industry. The development of the scientific base made it possible to form rational forest management, expand the range of opportunities for a deep wood raw materials processing and bring the production of the timber industry to a leading position on the world stage. As a result, due to rational forest management and deep wood raw materials processing, the timber industry in these countries has become unique and leading in the world. This was largely facilitated by a competent state policy.
It is worth paying attention to the fact that the current development of countries in the field of the timber industry boils down to the main idea – the possibility of implementing waste-free production programs and reducing the number of deforestation. Russia needs to adopt international experience of forest management based on the principles of the circular economy in order to avoid the disaster of deforestation. The country - the Krasnoyarsk territory is a case in point - needs to move away from the orientation of the raw materials and switch to waste-free production, in order to minimize waste at the enterprises by full use of resources. Transformation should consist of long-term measures. Firstly, we have to start raising public awareness about the value of these changes. What harm can such wasteful production do to human health and nature? Secondly, it is also necessary to organize fundamentally new chains of interaction between enterprises based on waste-free and secondary production.

For timber industry in the Krasnoyarsk territory, the authors have developed a conceptual model in the form of a series of activities based on the Strategy for Development of Industry for Sorting, Recycling and Treatment of Waste for the period until 2030, which are interlinked and complementary elements. These measures are appropriate and sufficient to transform the management system for the development of the timber industry:

- Forest protection and guarding: sanitation and hygiene measures to regenerate woodland after logging and fires;
- Forest renewal: development of high-quality forest seed farming in the region;
- Climate policy: allocation of protective forests with the establishment of an appropriate regime for their use;
- The profitability of forestry: pricing policy of forest use;
- Computerization of forestry: joining the region to the Unified State Automated Information System of accounting of wood and transactions with it (EGAIS);
- Logging activities: creating a unified territorial scheme of harvesting planning;
- Waste retrievability generated at all stages in the production process; and use of waste as raw materials for secondary production;
- Creation of a mandatory database at all enterprises for the production of briquettes, fibreboard, particle board, plywood, fuel pellets, wood chip from the extracted waste of the timber industry.

In addition, strict control over compliance with the requirements for complete extraction of waste must be achieved.

During the production process, at the stages of sawmilling and woodworking, a large amount of wood waste is generated, which in turn is deposited in landfills or even ends up in the wastewater. These actions entail not only anthropogenic and environmental consequences but also economic losses. Therefore, we propose to implement a closed loop model of the technological process in the timber industry. This model is presented in figure 3. Work on high-quality extraction of generated wood waste including waste located in the wastewater of enterprises should be engaged.

According to our proposed model of the technological process of wood processing, wood waste should be used in the production of enterprise products (fibreboard, particle board, plywood, fuel pellets, wood chip, etc.). Currently, many enterprises have room for the production of these products. For instance, extracted wood fibre from the wastewater of enterprise can be used in the manufacturing fibreboard products by wet processing.

In the scientific work [8], the authors considered a model of structural transformation in the management of the military-industrial complex. It was proposed to switch to a matrix management structure. This management model is also applicable to solving the problem discussed in this article. It is assumed that the principles of the control of dual management will prevent the formation of waste in production and eliminate wasteful production as a whole.
Figure 3. A closed loop model of the technological process in the timber industry.

5. Results
As a result of the conducted research, we can conclude that a closed-loop model of the timber industry proposed by us leads to the achievement of the main goal of the circular economy. This means the conservation of natural resources by the most rational management of it, and efficient use of waste that does not go beyond production. This organizational proposal allows enterprises to achieve the main goal. Moreover, that can bring real benefits for enterprises, such as improving competitiveness and financial stability by reducing production costs due to decreased raw material costs.

In addition, the enterprises of the timber industry are responsible for conducting forest management activities: forest tending, seed farming, forest protection and guarding, regeneration, cultivation of planting material, cruise (forestry examination), withdrawal of timber cutting areas, etc.

These steps will help the Krasnoyarsk territory to achieve the goals set in the Strategy for Development of Industry for Sorting, Recycling and Treatment of Waste for the period until 2030.

6. Conclusion
Thus, we have made projections taking into account international experience. The effectiveness of this project can be determined only after its practical application. These projections are problematic and mixed since the implementation of this model will be gradual, which is why it is difficult to assess the results.

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