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SIMULATION OF THE SUSTAINABLE FUNCTIONING OF WOOD FUEL WAREHOUSE

The article produced imitation modeling which allows to determine the optimum value was significantly off-season supply of fuel wood as a user stock, and at intermediate warehouses of the enterprises in the light of uneven supply and consumption of raw materials during the year, humidity, and loss of wood substance during long-term open-cumulus storage covering areas such as warehouse and used a system of machines. With the use this method is possible to solve design problems between seasons storage of firewood without capital construction costs, the definition of load-store and used machines for a year.

Introduction. On average Belarus consumes energy equivalent of 35 million tons of fuel per year and only 16% is provided with its own resources. The annual cost of imported energy resources (FER) exceeds $ 2 billion. To enhance energy security of the country from external suppliers of FER is a strategic objective for the country for the next five years. Realization of the potential of wood fuel in Belarus, which is a renewable source of energy will further cover up to 12–14% of its energy needs, solve the problem of utilization of waste in timber industry, create new working places, reduce the emission of pollutants into the atmosphere [1, 2].

The solution of this problem is complicated due to the irregularity and stochasticity of the process of harvesting and consumption of wood raw materials, lack of practical experience in the joint gathering of assortment and fuel wood, and the necessity of use for these purposes one and the same system of machines. Sustainable supply of power plants by wood fuel, the seasonal nature of its production and consumption makes possible to create off-season storage of firewood.

Designing of intraseasonal warehouses without regulatory base leads to an overestimation or underestimation of fuel, disruption in supply and increase in the cost of energy [3, 4].

1. Simulation of functioning of intraseasonal storage of firewood. For the purpose of integrated assessment of the collection, transport, storage, milling and wood fuel consumption, which are characterized by stochasticity of the process, necessity of operation of systems of machines in different natural and industrial environments, as well as changes over time in the characteristics of the wood open storage, the algorithm of calculating the probabilities of state warehouse wood and common unit operating costs, takes into account the above factors [5].

To assess the operation of enterprise storage between seasons with different capacities and the annual consumption of raw materials, the concept of the relative capacity of the warehouse is introduced. This parameter is a dimensionless value, and expresses the possibility of placing off-season supply of wood fuel in the amount of the average monthly production volume [5].

In order to study the optimal capacity of the off-season storage of firewood a mathematical model in which the warehouse is considered as a system of "supplier (vehicle) – storage of firewood – the consumer (boiler or mini-power plant)" of limited capacity was developed. For this system, the state of the basic phases at the end of each month, monthly coefficients are characterized by irregularity of supply and consumption. The proposed model works with the assumption that the amount of supplies of wood fuel and its consumption for the year are equal.

We derive the objective function unit of operating costs of maintaining off-season storage of wood fuel, which takes into account the probability of lack of raw materials in the warehouse and its overflow, depending on the relative capacity of the warehouse, parameters of supply, and consumption of wood fuel, the system of used machinery and infrastructure, the optimality criterion is chosen.

2. The results of simulation of functioning of intraseasonal storage of firewood. As an example, taking into account the previously established laws and the distribution functions of the coefficients of uneven supply (KP) and burning (Kc) of timber for storage of the municipal utilities of the Vitebsk region, Gorodok municipal utilities, and Vileyka mini-power plant with a simulation model of the wood fuel warehouse the computer calculated the probability of a lack of raw wood in stock (P1) and overflow (P2) depending on the relative capacity of the warehouse off-season storage of wood fuel (W). To get the result with certainty 0.99 the required number of iterations was calculated. The number of repetitions for each value is 1200, corresponding to 100 years of off-season storage.

Results are presented graphically in Fig. 1.

Fig. 1 shows that the probability of overflow storage of wood fuel (P2) and the lack of it in stock (P2) for the various companies is sharply reduced

with the increase of the relative storage capacity of up to 3.5–4.5 average monthly income for a raw material, regardless of its capacity and location. In the future, this decline is inconsiderable.

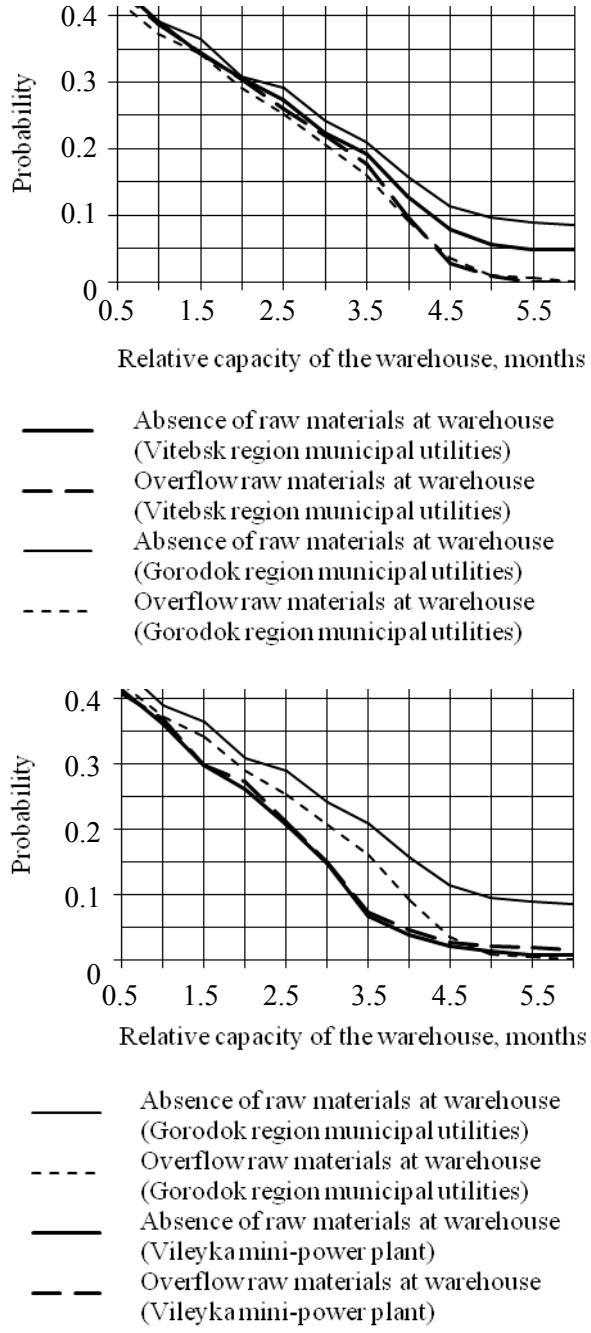

Fig. 1. Dependance of probabilities of absence of raw materials at warehouse and overflow raw materials at warehouse on relative capacity of the warehouse

Thus, the increase in the relative capacity of the storage housing W in Vitebsk region and in Gorodok mini-power plant from 0.5 to 4.5 average monthly production volume decreases P1 from 0.45 to 0.08 (82%) and from 0.45 to 0.11 (75%), respectively, and a decrease P2 from 0.45 to 0.03 (93%) and from 0.43 to 0.04 (90%), respectively. With a further increase to 6.0 W monthly production values P1 and P2 reduced only to 0.05, 0.09, 0.01 and 0.01, respectively (7, 5, 5, and 7%).

Increase in the relative capacity of the warehouse W Vileyka mini-power plant from 0.5 to 3.5 average monthly production decreases P2 P1 and from 0.41 to 0.07 (83%) and from 0.41 to 0.08 (on 80%), respectively. With a further increase to 6.0 W monthly production values P1 and P2 reduced only to 0.01 and 0.02, respectively (14 and 15%).

Significant effect on the probability of the data limits (P1 and P2) has wood turnover of warehouse and its geographical location. On the basis of these studies it was found that for larger providers and consumers of wood fuel in the south of the country, these probabilities are much lower than for the smaller north of the country. Thus, when W amounts 4.5 monthly production volume, the probabilities P1 and P2 of Gorodok municipal utilities by 27% and 25% are respectively, higher than the utility of the Vitebsk region, and by 82% and 25%, respectively, are higher than Vileyka mini-power plant.

Probabilities for lack of raw materials in stock (P1) and overflow (P2) allowed on the basis of the objective function to determine the optimal storage capacity of the enterprise in wood, calculated by computer.

The target function in addition to the probability parameters, which vary depending on the relative capacity of the storage of wood fuel, comprise also permanent economic parameters of its operation (taken as the average production for Belarus).

In Fig. 2 on the basis of the developed mathematical models and computer calculations, the optimal values of the relative capacity of different intraseasonal storage of firewood are presented.

Fig. 2 shows that the stable and efficient operation of warehouses of intraseasonal wood achieved due to the capacity and location, providing their relative capacity within 3.5-4.5 average monthly production volume.

When Vitebsk and Gorodok municipal utilities increased the relative capacity of the storage of firewood from 0.5 to 4.5 average monthly production, unit operating costs were reduced for 33% and 29% respectively. A further increase in the relative storage capacity from 4.5 to 6.0 average monthly production leads to an increase in unit operating costs for 19% and 18%, respectively, primarily due to rising operational costs of maintaining the site of the warehouse. For Vileyka mini-power plant increase of capacity of the relative stock of firewood from 0.5 to 3.5 average monthly production unit reduce operating costs for 38%. A further increase in the relative storage capacity from 3.5 to 6.0 average monthly production leads to an increase in unit operating costs for 31% for a similar reason.

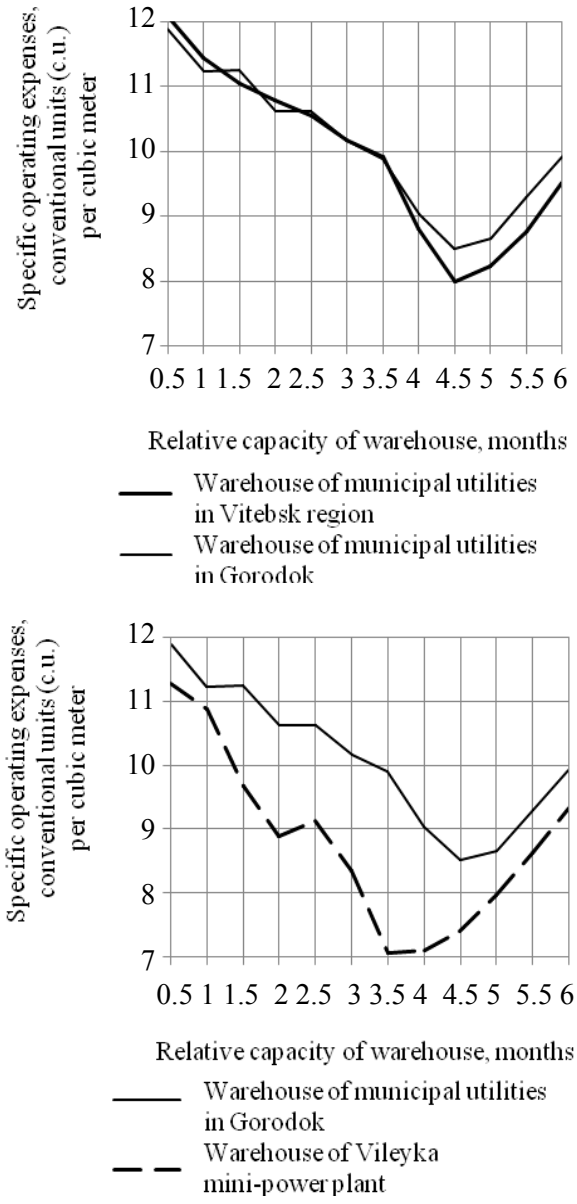

Fig. 2. Determination of target function of specific operating expenses, when wood is stored in the warehouse without any intermediate storage

For consumers of wood fuel in the south of the country a relatively smaller capacity is required (3.5 average monthly production), if compared to consumers in the north of the Republic (4.5 average monthly production volume). Annual unit operating costs for consumers in the southern Belarus are 15–20% lower than in the northern Belarus.

Large consumers (mini-power plants) of wood fuel which are located, for example, in regional or major regional centers, face the problem of lack of space for the construction of storage of required capacity (3.5–4.5 average monthly production volume). The solution of this problem is the use of intermediate warehouses, which are located outside the city, but have reliable transportation to the warehouse users. In this case some wood is stored in intermediate storage, and some – in the customer stock.

To determine the optimal values of intraseasonal supply of wood fuel at different ratios (intermediate storage / warehouse user) of raw materials shares in the developed model, we performed a series of studies. The results concerning Vileyka mini-power plant are shown in Fig. 3.

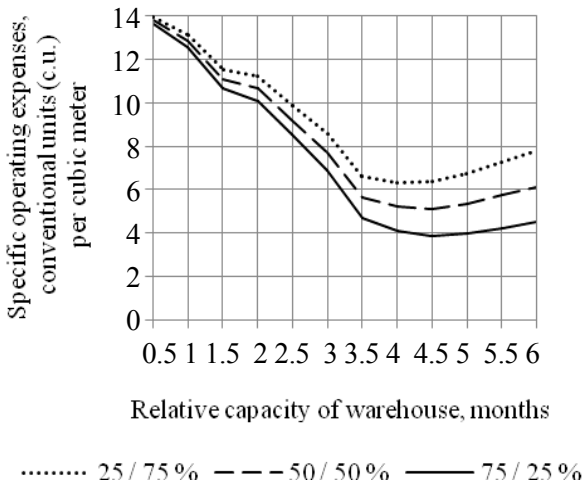

Fig. 3. Determination of target function of annual specific operating expenses in the organization of supply of wood fuel warehouse with intermediate storage in Vileyka mini-power plant

Fig. 3 shows that, for the effective implementation of sustainable supply of wood fuel it is reasonable to reserve materials placed on intermediate storage at roads of all-year-round use. It will give a significant reduction (2–2.2 times) of annual unit operating expenses.

An important practical value of the target function is the lack of a pronounced minimum. This allows you to adjust the wide range of storage capacity of wood without the risk of significant growth in cash costs. This range of regulation is a preferred orientation in the direction of increasing the relative capacity of the warehouse W where storage costs are relatively low.

Conclusion. 1. Assessment of sustainable energy facilities with wood fuel is made with the use of storage between seasons (with or without intermediate storage) for the most common conditions of the Republic of Belarus, the system of used machines, the type of coverage of warehouse area, peculiarities of storage of wood fuel.

2. Based on the results of theoretical and experimental investigations simulation of off-season storage of wood fuel is carried out. Taking into account the availability of intermediate storage it is ascertained that:

– The probability of overflow storage wood for fuel and lack of it in stock decrease sharply

with increase of relative storage capacity to 3.5–4.5 average monthly income for a material which ensures a stable and efficient operation of power facilities;

– The extreme value of the target function of unit operating costs are also achieved when the off-season supply over 3.5 monthly production volumes is available;

– For mini-power plant in the south of Belarus, an optimal relative storage capacity of wood will be less by 15–20%, than for the boiler industry and regional enterprises;

– Taking into account the significant costs for the bulk of consumer storage off-season warehouse it is advisable to place the stock in the intermediate storage, which will allow to make annual costs 2–2.2 times lower to maintain it.

References

1. Государственная программа строительства энергоисточников на местных видах топлива в 2010–2015 годах: утв. постановлением Совета Министров Респ. Беларусь 19.07.2010. – Минск, 2010. – 33 с.

2. Республиканская программа энергосбережения на 2011–2015 годы: утв. постановлением Совета Министров Респ. Беларусь 24.12.2010. – Минск, 2010. – 80 с.

3. Официальный сайт Министерства лесного хозяйства Республики Беларусь [Электронный ресурс]. – Режим доступа: http://www.mlh.by. – Дата доступа: 07.10.2011.

4. Леонов, Е. А. Модель склада древесного топлива / Е. А. Леонов // Труды БГТУ. – 2011. – № 2: Лесная и деревообр. пром-сть. – С. 135–139.

5. Леонов, Е. А. Оптимизация вместимости склада межсезонного хранения древесного топлива / Е. А. Леонов, А. С. Федоренчик // Деревообработка: технологии, оборудование, менеджмент XXI века: труды III Междунар. евразийского симпоз. / под науч. ред. В. Г. Новоселова. – Екатеринбург, 2008. – С. 62–66.

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