Renovation of the tractor fleet in the agriculture of the region

N I Selivanov, V A Veryanov¹, A V Kuznetsov, N V Kuzmin and V N Zaprudsky
Krasnoyarsk State Agrarian University, 90 Mira Av. Krasnoyarsk, 660049, Russia

¹E-mail: vaveryanov@bk.ru

Abstract. The article examines the prospect of renewing the tractor fleet in the agriculture of the Krasnoyarsk Territory. It is based on the assessment of the actual composition and renewal of the tractor fleet over the past five years using the developed models for the formation of tractor availability in production. In the period from 2016 to 2020 the annual fleet reduction was 2.90%, with a decrease of 4.76% and a renewal of 1.86%. Tractor availability decreased from 3.40 to 3.27 reference units per 1000 hectares of arable land with practically unchanged age composition and amounted to 69.3% of the norm. A significant reduction in the number of the tractor fleet is compensated by its renewal due to the purchase of wheeled tractors of higher power than those that have departed. The existing rates of renovation do not allow to form in the near future even the basis of the innovation park. It needs to be updated with a simultaneous increase in the number of the main standard sizes of tractors. The average annual increase in the number of tractors in the fleet should be 105 physical or 271 reference units. The total number of the innovation park is 7869 physical or 8708 reference units with a conventional conversion factor of 1.107 and a standard tractor supply of 4.718 reference tractors per 1000 hectares of arable land. The indicated indicators of renewal will make it possible to form the composition of the innovative tractor fleet of the region by 2030.

1. Introduction
The Krasnoyarsk Territory is located in the agricultural zone 6.2 of the Siberian Federal District (SFD) and is one of the main producers of crop products with the highest grain yield in 2020 of 32.0 c / ha, achieved through the introduction of technologies for their production adapted to the natural production conditions of the main commodity producers. The basis of the tractor fleet in the agriculture of the region is represented by a set of different types and sizes of mobile energy devices for the formation of tillage, sowing, harvesting, transport and other units in the mechanization of production processes in crop production. The rational size range and composition of the tractor fleet, ensuring the food independence of the region, is determined by the normative need of model farms in the main natural zones [1-4]. In recent years, the problem of modernization and the formation of an innovative tractor fleet by replacing morally and physically obsolete machines with new models with improved technical characteristics [5-6], providing an increase in the efficiency indicators of units based on them, has acquired particular relevance.

2. Problem statement
The goal of the work is to assess the state and prospects of updating the tractor fleet in the agriculture of the region.

Achievement of this goal involves solving the following tasks:
1) to assess the actual state of the tractor fleet;
2) to determine prospects for renewal and formation of an innovative tractor fleet.

3. Research methods

The structure of the solution of the set tasks includes [2,5]:

1) establishment of actual indicators of the structure, condition and renewal of the fleet of free tractors;
2) justification of the standard size range and the composition of the innovative tractor fleet;
3) determination of rational indicators of renewal for the formation of an innovative tractor fleet.

The main parameters of the tractor park of rural commodity producers and the region as a whole are its structure and composition, which in the process of operation are continuously changing due to the retirement of obsolete and worn-out ones with the simultaneous acquisition of new models. Changes in the actual composition of the fleet for the reporting period (one year) characterize the initial $\sum_r^n_{ph, i}$ and the final $\sum_r^n_{f, i}$ number of physical tractors of different standard sizes $r$ with known acquiring of new $\sum_r^n_{ph, i}$ and departed $\sum_r^n_{ph, d}$, the ratio of which determines a new level of tractor availability in physical $n_{ph}$ and reference $n_{ref}$ units. [7-9] as the main indicator of renewal and formation of an innovative park. Taking into account the change in the arable land $F_0 = F_{af}/F_{ap}$ the number of tractors of each of the main standard sizes $n_{ph, i}(n_{ref, i})$ and the total supply $n_{ph}(n_{ref})$

$$
\begin{aligned}
& n_{ph, i} = \sum_{T=1}^T n_{ph, i} \cdot 1000/F_a; \\
& n_{ph} = \sum_{T} n_{ph, i} \cdot 1000/F_a; \\
& n_{ref, i} = n_{ph, i} \cdot K_{r, i}; \\
& n_{ref} = n_{ph} \cdot K_r,
\end{aligned}
$$

with the corresponding values of the conditional coefficient of conversion of physical tractors to reference $K_{r, i}$ and $K_r = \sum_r^n_{ph, i} \cdot K_{r, i}/n_{ph}$.

The indicators that determine the tractor availability in reference units have the form

$$
\begin{aligned}
& n_{ref, p} = \sum_T n_{ph, pi} \cdot K_{r, p} \cdot 1000/F_p; \\
& n_{ref, f} = \sum_T n_{ph, fi} \cdot K_{r, f} \cdot 1000/F_f; \\
& n_{ref, n} = \sum_T n_{ph, ni} \cdot K_{r, n} \cdot 1000/F_f; \\
& n_{ref, d} = \sum_T n_{ph, di} \cdot K_{r, d} \cdot 1000/F_f.
\end{aligned}
$$

Their ratios in absolute and relative units, determining the change in the composition of the fleet

$$
\begin{aligned}
& n_{ref, p}/F_0 + n_{ref, n} - n_{ref, d} = n_{ref, f}; \\
& \lambda_p + \lambda_n - \lambda_d = 1; \\
& \Delta\lambda_n = 1 - \lambda_p,
\end{aligned}
$$

where $\lambda_p = (n_{ref, p}/n_{ref, f}) \cdot F_0; \lambda_n = n_{ref, n}/n_{ref, f}; \lambda_d = n_{ref, d}/n_{ref, f}$.

With the established indicators of the actual $n_{ph}(n_{ref})$ and normative $n_{ph}^*(n_{ref}^*)$ tractor availability with a given duration of the formation of the innovative park $T_0$, the annual update of the main standard sizes will be determined as
\[
\begin{align*}
\Delta n_{ph}^* &= \left( n_{ph}^* - n_{ph} \right) / T_0; \\
\Delta n_{ref}^* &= \Delta n_{ph}^* \cdot K_{r, i}.
\end{align*}
\]

Updating the entire fleet forms indicators

\[
\begin{align*}
\Delta n_{ph} &= \left( \sum_T n_{ph}^* - \sum_T n_{ph} \right); \\
\Delta n_{ref} &= \sum_T \Delta n_{ref}^*,
\end{align*}
\]

with the conditional coefficient \( \bar{K}_r = \Delta n_{ref}^*/\Delta n_{ph}^* \).

The above indicators taken as a basis allow us to determine the conditions for the formation of an innovative tractor park in the region.

4. Research results

Based on the assessment of changes in the structure and composition of the fleet of free tractors of rural producers in the region for 2016–2020 (table 1) [1], it was found to decrease by 14.48%, with a decrease of 23.79% and an update of 9.31%, which amounted to 2.90, 4.76 and 1.86 %, respectively.

Tractor availability of production decreased at the same time from 3.98 to 3.69 or \( n_{ref} \) from 3.40 to 3.27 units / 1000 ha (3.98%), which amounted to an average annual rate of 0.80% with a decrease in arable land area of 0.88%.

The age composition of the tractor fleet during this period practically did not change for new (up to 3 years) equipment, no more than 11.0%, and with a service life of more than 10 years – 70.0% [2-3].

### Table 1. Renewal of the fleet of free tractors in agriculture of the Krasnoyarsk Territory.

| Year (01.01.) | \( \sum_T n_{ph}, \) units | \( \sum_T n_{ph}^*, \) units | \( \sum_T n_{phd}, \) units | \( \bar{K}_r \) | \( F_a, \) thous. ha | \( n_{ref}, \) units / 1000 ha | \( \lambda P_{ph}, \) % | \( \lambda n_{ref}, \) % |
|--------------|-----------------|-----------------|-----------------|---------|-------------|-----------------|-------------|-------------|
| 2016         | 7647            | 153             | 266             | 0.856   | 1926.8      | 3.40            | 2.03        | -0.29       |
| 2017         | 7534            | 114             | 188             | 0.860   | 1912.1      | 3.39            | 1.53        | 0.0         |
| 2018         | 7460            | 112             | 442             | 0.865   | 1906.1      | 3.39            | 1.57        | 0.0         |
| 2019         | 7130            | 143             | 453             | 0.875   | 1845.8      | 3.38            | 2.10        | -0.30       |
| 2020         | 6820            | 100*            | 240*            | 0.885   | 1845.8      | 3.27            | 1.50        | -3.36       |

* Preliminary data.

The above indicators of the tractor availability of agricultural production in the region indicate that it is practically unchanged over the past five years, which is 69.3% of the norm. A significant reduction in the tractor fleet is compensated by its renewal due to the acquisition of mainly wheeled tractors of higher power.

The existing rates of renovation will not even allow to form the basis of an innovative tractor fleet in the near future. It requires renewal of the fleet with a simultaneous significant increase in its number.

A comparative assessment of the actual and standard tractor supply at \( F_a = 1845.8 \) thousand hectares made it possible to substantiate the intensity of renewal of the main standard sizes of wheeled tractors to form the structure and composition of the innovative tractor fleet of agriculture in the region by 2030 (table 2).
Table 2. Tractor availability of agriculture in the Krasnoyarsk Territory.

| Size / wheel arrangement | $N_{ap}$, kw | $R_r/\bar{K}_r$ | $\sum n_{ph}$, units/1000 ha | $n_{ref}$, units/1000 ha | $\sum n_{ph}$, units/1000 ha | $n_{ref}$, units/1000 ha | $\Delta n_{ph}/\Delta n_{ref}$ |
|--------------------------|--------------|----------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------------|
| 0.6-1-0.92               | 30-50        | 0.33           | 308                         | 0.055                       | 0                           | 0                           | -30                           |
| 4k2                      | 47-67        | 0.49           | 3228                        | 0.885                       | 3112                        | 0.826                       | -13                           |
| 4.4.4-2.4                | 51-100       | 0.63           | 293                         | 0.100                       | 777                         | 0.265                       | +48                           |
| 4k4a                     | 101-150      | 1.08           | 413                         | 0.242                       | 178                         | 0.104                       | -18                           |
| 4k4a                     | 151-200      | 1.32           | 254                         | 0.182                       | 301                         | 0.215                       | -19.5                         |
| 3.6-4.6                  | 133-165      | 1.50           | 950                         | 0.772                       | 950                         | 0.772                       | 0                             |
| 4k4a, 4k4b               | 201-250      | 1.63           | 143                         | 0.126                       | 781                         | 0.690                       | +64                           |
| 4k4b                     | 166-200      | 1.86           | 118                         | 0.119                       | 1340                        | 1.350                       | +106                          |
| 4k4b                     | 251-300      | 2.13           | 166                         | 0.192                       | 430                         | 0.496                       | +26                           |
| 4k4b                     | 201-245      | 2.53           | 60                          | 0.083                       | 0                           | 0                           | +12.7                         |
| 4k4b                     | 301-350      | 1.13           | 887                         | 0.541                       | 0                           | 0                           | -88                           |
| Total                    | 885          | 6820           | 3.27                        | 7869                        | 4.718                       | +105                        | +271                          |

The basis of the annual update is a significant increase in the number of wheeled tractors of standard sizes 6.9-8.9 (132 units), 4.8-5.8 (64 units) and 1.4.4-2.4 (48 units) with a reduction in the size of wheeled tractors 0.6.1-0.9.2 (-30 units), 0.9.2-1.4.3 (-13 units), 2.5-3.5 (-18 units), and tracked 3.3-4.3 (-88 units). This leads to an average annual increase in the number of tractors in the fleet by 105 physical or 271 reference units at $\bar{K}_r=2.58$. The total number of the innovation fleet is 7869 physical or 8708 reference units at $\bar{K}_r=1.107$ and $n_{ref}=4.718$ units / 1000 ha.

Achievement of standard tractor availability in the region for the specified period requires an annual increase in the number of reference and physical tractors by 4.43 and 1.53%, respectively, with an increase in the average power of the latter by 2.50%.

5. Conclusion
1. Based on the results of assessing the main indicators of the tractor fleet in the agriculture of the region using the developed models, it was found that the actual structure and renewal of the composition over the past five years provide the normative production requirement at the level of 69.3% with an annual decrease in the number by 0.80%.

2. To form an innovation fleet, the average annual increase in the number of tractors of the main standard sizes should be 105 (1.53%) physical or 271 (4.43%) reference units, this will make it possible to achieve the standard provision of 4.718 reference units / 1000 ha by 2030.
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