The Configurations Coordination of the Projects Products of Development of the Community Fire Extinguishing Systems with the Project Environment

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Abstract

Proposed method of configuration grounding of fire extinguishing or fighting systems of the territorial communities in the desired state is based on the conceptual and simulation models of the proposed fire extinguishing system. The effective type of fire station and its optimal location on the territory of the united territorial community are determined by the comprehensive criterion of exposure to fire of settlements, taking into account the changing configuration of the project environment (the number of inhabitants in settlements, the presence of fire hazard facilities and the characteristics of the roads network). On the base of simulation of projects of fire extinguishing system the specific scenarios of this system development are worked out. The scenarios of the fire extinguishing system development with first (I) category of fire companies are more effective than with fire brigades. Regarding the territorial location of fire depots, the minimal average trip time of fire unit to the place of fire are ensured by variants of fire formation location in defined place.

Keywords 1

Fire extinguishing system, project, configuration, community

1. Introduction

Creation of effective extinguishing systems in Ukraine is one of the priority directions of the state activity that ensures the security of life and health of people, as well as material values and the environment [1]. Today in Ukraine scientists and practitioners pay much attention to the state of the existing extinguishing systems, as well as to the current importance problem of its development [2, 9-10, 12-15, 17-25]. And the importance will increase with further development of rural territories and agricultural enterprises and also the system of civil defence system in Ukraine [13-14].

The urgency of the research is confirmed by the analysis of the distribution of the number of fires and the number of deaths and injured persons at fires by types of locations on the territory of Ukraine during of 2018-19 years (Fig. 1-2).

The distribution of the number of fires by type of locations on the territory of Ukraine suggests that large part (34.4%) of the total number of fires (Fig. 1) are at rural areas. The distribution of the number of fatalities from fires (Fig. 2) is suggested that rural settlements are most vulnerable to fires. The share of fatalities from fires in rural areas is 55.6% of the total number of deaths. Also, in the number of fatalities in rural settlements in recent years the dynamics has a stable and unvarying negative tendency. In particular, the number of fire deaths in rural areas in 2019 increased by 92 (or by 9.7%) compared with 2018.

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It is known, the vast majority of rural settlements are not protected to fire [5]. In particular, the trip time of fire brigade to the place of fire in the countryside significantly exceeds its permissible value of (20 min.). This is largely due to the territorial location of rural settlements (the average distance to the nearest fire and rescue unit ranges from 30 to 40 km) and the condition of the external and internal roads of rural areas as well.

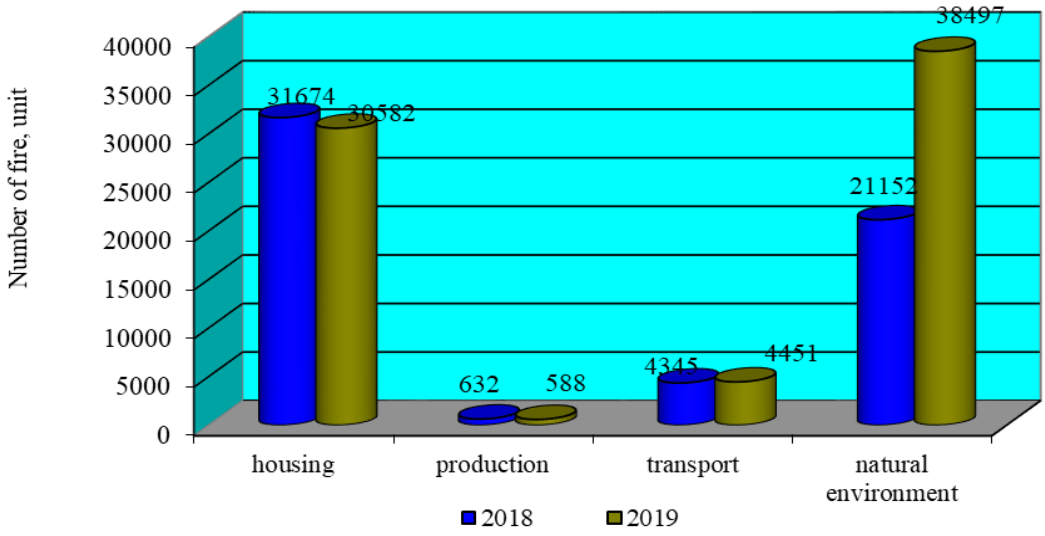

Figure 1: The distribution of the number of fires by types of location on the territory of Ukraine during of 2018-2019 years

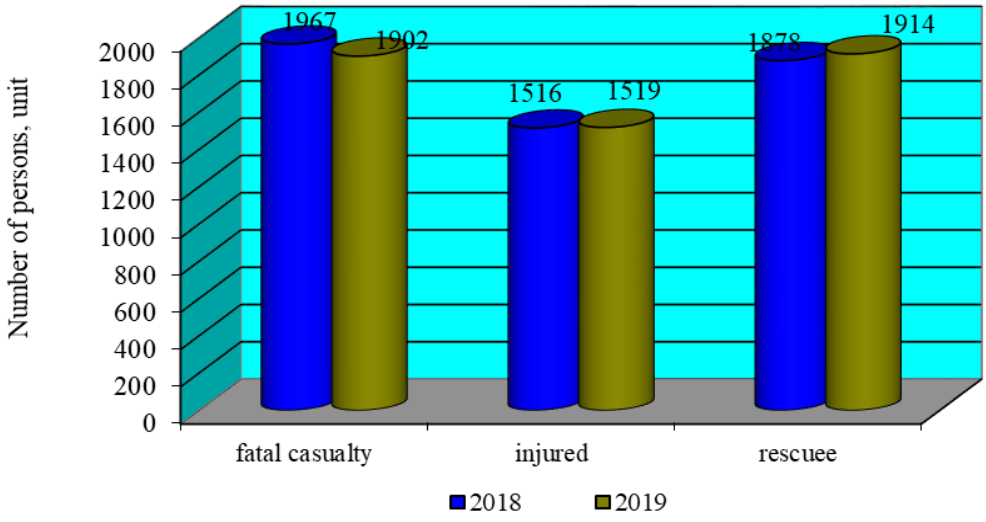

Figure 2: The distribution of the number of fire fatalities and injured on the territory of Ukraine during of 2018-2019 years

Based on the analysis of the functioning of fire fighting systems in European countries, it can be argued that they are predominantly formed by local authorities and voluntary fire brigades dominated largely there [4, 8]. Such fire brigades have both the voluntary firemen and part-time involved workers [5].

Foreign experience showed that voluntary fire brigades have been created in almost all European countries. Voluntary fire brigades combine efforts and resources of local residents of certain

territories in order to prevent the emergence and, if necessary, extinguish and suppress the fire.

The analysis of structure of the fire fighting system in the European countries reveals that the professional fire formation is prevailed in number the voluntarily fire extinguishing units (except of Great Britain). It gives an opportunity to ensure the efficiency of functioning of the fire extinguishing systems in these countries and fire security of territories, population and stocks of materials and capital equipment. Except that, a voluntariness and volition in the countries of Europe are the civic and patriotic duty of citizen of the state.

For the voluntarily fire formations in European countries the according terms are created. In particular, in European countries the proper stimulation of firemen is provided and at legislative level the norms of law and terms are created for their social protection.

On the basis of analysis of the selected statistical data in relation to the state of the fire extinguishing system in Ukraine, it is possible to conclude, that this system functions uneffective and requires of reengineering. Especially it is concerned the fire extinguishing systems of rural settlements that are most exposure to fire. Analysis of the state of the fire extinguishing systems in the countries of Europe testifies that for protection of rural settlements the voluntarily fire formations are created in the countries of the European Union and USA. On the basis of analogy the priority directions of development of the fire extinguishing system in Ukraine is the creation of the voluntarily fire formations on territory of united territorial communities (UTH).

2. Analysis of literature data and problem statement

Grounding of configuration of the fire extinguishing system of united territorial communities in the desirable state and the assessment of their value is based on the current state strategy of reforming the system of the State Emergency Service of Ukraine [9]. The proposed scheme of reasoning of the fire extinguishing systems configuration contains the stages of developing a conceptual model of the desired UTH fire extinguishing system, as well as simulation of the projects of the operation of the UTH fire extinguishing system.

The argumentation of the configuration of the UTH fire extinguishing system in the desirable condition is to determine the type and parameters of the fire-station, as well as its location on the territory of the community. At the same time, it should be take into consideration that "The Procedure for the Functioning of Voluntary Fire Prevention" (Resolution of the Ministers Cabinet of Ukraine No. 584 of 17.07.2013) [10] provides the possibility of creating the five types of specialized units for fires extinguishing in the territory of the community. The characteristics of types of the fire extinguishing units have been shown on Fig. 3.

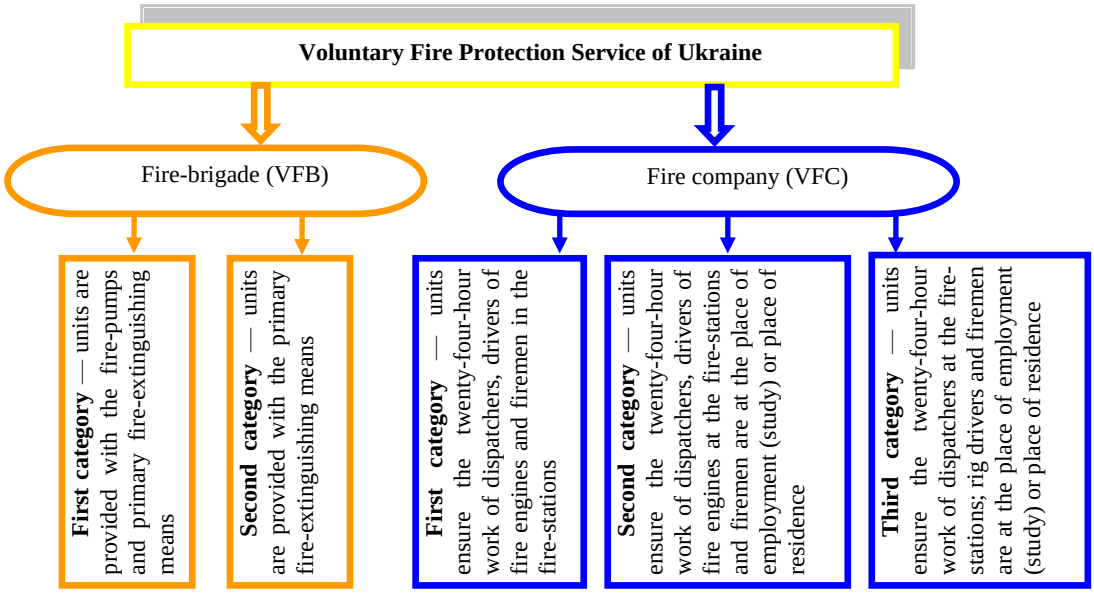

Figure 3: Types of units of the Voluntary Fire Protection Service of Ukraine

Fire progression and total losses (material losses and losses of people) depend on the duration of the movement (trip time) of fire and rescue units to the places of fire. Therefore, the territorial location of the fire depots on the territory of the UTH is needed to be determined. For this purpose, the criterion of the trip time of fire and rescue units to the places of fires is proposed [11].

The basis for determining the territorial location of fire depots on the UTH territory was the known method [18]. This method has a number of advantages compared with other methods of determining the location of fire-stations on a prescribed administrative territory. With regard to determining the territorial location of fire depots in the UTH territory, this method takes into account the following: 1) settlements are not evenly situated on the UTH territory; 2) the number of inhabitants of separate settlements of the UTH is different; 3) settlements of the UTH are connected by the different types of roads (with a hard covering, without hard cover, etc.). This method is intended to determine the territorial location of fire and rescue units on the administrative district and does not take into account the peculiarities of the objects' configuration of project environment of the new UTH.

Also the known procedure takes into account the types of roads amongst the separate settlements of UTH, but does not take into account the real condition of these roads [11]. In the vast majority of rural settlements and areas, the roads with or without hard cover are partially or completely damaged, which greatly affects the time duration of arrival of fire and rescue units to the place of fire. In addition, the method does not take into account the time for the preparations of fire brigades (fire companies) before trip to the fire place in a specific settlement of UTH. This indicates the need to use a comprehensive criterion for determining the site of the territory location of fire depots in the locality of UTH, which would take into account both the number of inhabitants of rural settlements, and the time of arrival of fire brigades (fire companies) to the place of fire extinguishing.

Therefore, there is a need to develop a method of coordination of the product project configuration of the fire extinguishing systems development in the united territorial communities with the project environment. This method should systematically take into account the stochastic parameters of the project environment, the impact of aforesaid parameters on the grounding of configuration databases, the budget of relevant projects, as well as the value of the product project, which is quite relevant both scientifically and practically.

3. The purpose and objectives of the study

The purpose of the work is to develop a method of coordination the projects products configuration for development of the UTH fire extinguishing systems with the project environment. On the base of proposed method use we plan to determine the rational configuration of the project product for a given project environment.

In order to achieve the purpose in the work the following tasks are needed to be solved:

- to propose a method of coordination of the projects product configuration for the development of fire extinguishing systems of the united territorial communities with the project environment; this method must take into account the stochastic effect of the components of the project environment, as well as components impact on the configuration bases, budget and product value of these projects;
- on the basis of the use of the proposed method and the project environment one needs to ground the rational configuration of the project product for development of the fire extinguishing system of the united territorial community.

4. The method of configuration coordination of the projects product for the development of the fire extinguishing systems of the united territorial communities with the project environment

The level of fire unprotectedness (exposure to fire) (R_{Hj}^{m}) of territory with *j*-th settlements is proposed as the criterion for determining the site of the territory location of fire depots in the locality of *m*-th UTH. In works of [14-15] this index is suggested to calculate according to the expression:

$$R_{нj}^{m} = n_{nj}^{m} \cdot t_{i,j}^{m}, \quad (1)$$

where $R_{нj}^{m}$ – the level of fire unprotectedness of the *j*-th settlements on the territory of *m*-th UTH, fire·hour; n_{nj}^{m} – the fire number at the *j*-th settlement, unit; $t_{i,j}^{m}$ – the duration of the movement (trip time) of fire and rescue units from the fire depots at the *i*-th settlement of *m*-th UTH to the place of fire at the *j*-th settlement (duration of free burning of objects), hour.

On the territory of *m*-th UTH the ($N_{нс}^{m}$) limited population are located. This population are dispersed on the territory of UTH *j*-th settlements:

$$N_{нс}^{m} = \left\{ n_{нс_j} \right\}, \; j = 1,n. \quad (2)$$

where $N_{нс}^{m}$ – the population on the territory of *m*-th UTH, persons; $n_{нс_j}$ – the population on the territory of the *j*-th settlements of *m*-th UTH, persons; n – the number of the settlements on the territory of *m*-th UTH, unit.

The condition of localization of the fire depot in one of the settlements is the minimum possible level of fire unprotectability of all settlements of *m*-th UTH ($R_{н}^{m} \to min$). To solve this task the next limitations and suppositions are assumed: 1) the technical equipment of the fire depots and its staff are depended of the organizational scheme of fire fighting system development in the UTH (look fig. 1); 2) the fire depots are located on the territory of one of the UTH settlements; 3) in one of UTH no more than one fire depot are located.

First of all, to determine the territorial location of the fire depot on the UTH territory the configurations of the project environment are researched. The settlements (n_i), the number of the settlements population ($n_{нс}$), objects of high fire hazard (n_o) in each of settlements, as well as a network of roads among settlements and in settlements are the objects of this project configuration. To solve this problem the objects of this configuration should be identified according to the known method [11].

Having the quantitative values of the characteristics of the project environment objects of the UTH fire extinguishing systems the annual number of fires (n_{nj}^{m}) in the *j*-th settlement can be predicted:

$$n_{nj}^{m} = f\left(n_{нcj}\right). \quad (3)$$

where n_{nj}^{m} – the annual number of fires (n_{nj}^{m}) in the *j*-th settlement of the *m*-th UTH, units; $n_{нcj}$ – the population on the territory of the *j*-th settlements of *m*-th UTH, persons.

The functional dependence (3) is grounded on the basis of statistical data of a separate administrative district in which the UTH is situated and this UTH needs to develop its own fire extinguishing system. At the same time, for settlements, which have objects of high fire danger the emergence of fires separately is predicted on the basis of the probability of fires in such the objects [11].

The territory of a separate UTH is described by a model (matrix) of the territorial location of settlements with a network of roads. The model is presented as a matrix of the shortest distances along the general roads among the individual settlements of this territory:

$$M_{L}^{m} = \left\{ L_{i,j}^{m} \right\}, i = 1,n, j = 1,n, \quad (4)$$

where M_{L}^{m} – the matrix of the shortest distances along the general roads among the individual settlements of the *m*-th UTH; $L_{i,j}^{m}$ – the distance along the general roads among the *i*-th and *j*-th settlements of the *m*-th UTH.

The convention is made that in each UTH the fire depot could be situated. To determine the distance on the general roads between the *i*-th settlements with fire depot and *j*-th settlement of the *m*-

th UTH which needs the fire protection, the algebraic expression is used:

$$L_{i,j}^{m} = l_{i_0,j_0}^{m} + \frac{l_i^m + l_j^m}{2}, \quad (5)$$

where l_{i_0,j_0}^{m} – the distance along the general roads from the beginning of the *i*-th and *j*-th settlements of the *m*-th UTH; l_i^m, l_j^m – the longest distance along the internal roads accordingly in the *i*-th and *j*-th settlements of the *m*-th UTH.

For each of the road branch of UTH road network the road pavement state is estimated. In particular, the type of road (with hard pavement and without it, with road gravel, earth road etc.) and its condition are determined on the basis of production experiments. For the roads of general purpose amongst the beginnings of settlements and the roads of the internal network of settlements the road type and coefficients ($k_{i,j}^{m}$) of road condition are determined by the formula:

$$k_{i,j}^{m} = \frac{\sum_{b=1}^{n} l_{i_b,j_b}^{m}}{l_{i,j}^{m}}, \quad (6)$$

where $k_{i,j}^{m}$ – the coefficient ($k_{i,j}^{m}$) of the road condition between the *i*-th settlement with the fire depot and the *j*-th settlements of the *m*-th UTH; $l_{i,j}^{m}$ – the distance between the *i*-th settlement with the fire depot and the *j*-th settlements of the *m*-th UTH; $\sum_{b=1}^{n} l_{i_b,j_b}^{m}$ – the total distance of damaged road between the *i*-th settlement with fire depot and the *j*-th settlements of the *m*-th UTH; b – quantity of damaged road section on the road between the *i*-th settlement with the fire depot and the *j*-th settlements of the *m*-th UTH.

A road condition of the separate UTH is described by a model in a view of the matrix of the road condition coefficients:

$$M_k^m = \left\{k_{i,j}^{m}\right\}, i = \overline{1,n}, j = \overline{1,n}, \quad (7)$$

where M_k^m – the matrix of the road condition coefficients amongst the separate settlements of the *m*-th UTH.

Having the models of territorial location of the settlements with the road network of the separate UTH (4) and the road condition on its territory (7) the matrix of the trip time of the fire fighting and rescue brigades to the fire places could be formed:

$$M_t^m = \left\{t_{i,j}^{m}\right\}, i = \overline{1,n}, j = \overline{1,n}, \quad (8)$$

where M_t^m – the matrix of the trip time of the fire fighting and rescue brigades to the fire places of the *m*-th UTH; $t_{i,j}^{m}$ – the trip time of the fire fighting and rescue brigades from the place of location in the *i*-th settlements to the fire places in *j*-th settlements of the *m*-th UTH; n – the number of the settlements on the territory of the *m*-th UTH.

Trip time ($t_{i,j}^{m}$) of the fire fighting and rescue brigades from the place of depot location in *i*-th settlements to the object of fire in *j*-th settlements of the *m*-th UTH is determined by the formula:

$$t_{i,j}^{m} = t_{in} + t_з + t_д + t_{дb} + t_н + t_{нb} + t_p, \quad (9)$$

where t_{in} – the time interval from the fire start to the fire depot informing about the fire in the certain place, hour; $t_з$ – the time interval of fire brigade preparing to the brigade departure to extinguish the

fire, hour; $t_{\partial}, t_{н}$ – accordingly the trip time of the fire and rescue units on the roads without damage of pavement amongst the settlements and at the settlement territory, hour; $t_{\partial b}, t_{нb}$ – accordingly the trip time of the fire and rescue units on the roads with damaged pavement amongst the settlements and at the settlement territory, hour; t_{p} – the time interval of the fire brigade preparing to extinguish the fire at the fire object or emergency situation, hour.

Time interval or duration (t_i) from the point of the fire start to the fire depot information receipt depends of the localization of fire object on the UTH territory, the period of year (season) and day and night, availability the means of communication etc. Time interval ($t_з$) of fire company (brigade) preparing to the departure to the fire extinguish place depends of organizational scheme of fire fighting system of the UTH (fig.1) and also of work effectiveness of the dispatcher service, labour discipline level, professional skills of members of fire company (brigade), technical state of the fire and rescue automobiles etc.

As to the trip time of fire and rescue units along the roads amongst the settlements of UTH and on the internal roads of the settlement territory, it has several constituents:

$$t_{\partial} = \frac{l_{i,j}^{m} \cdot \left(1 - k_{i,j}^{m}\right)}{V_{n}}, \tag{10}$$

$$t_{\partial b} = \frac{l_{i,j}^{m} \cdot k_{i,j}^{m}}{V_{nb}}, \tag{11}$$

$$t_{н} = \frac{l_{i}^{m} \cdot \left(1 - k_{i}^{m}\right) + l_{j}^{m} \cdot \left(1 - k_{j}^{m}\right)}{V_{н}}, \tag{12}$$

$$t_{нb} = \frac{l_{i}^{m} \cdot k_{i}^{m} + l_{j}^{m} \cdot k_{j}^{m}}{2V_{нb}}, \tag{13}$$

where $t_{\partial}, t_{н}$ – the trip time of the fire and rescue units accordingly on roads amongst the settlements of UTH and on the internal roads of settlement territory of the UTH, hour; $t_{\partial b}, t_{нb}$ – the trip time of the fire and rescue units accordingly on the roads with damaged pavement amongst the settlements of UTH and on the internal roads with the damaged pavement of settlement territory of the UTH, hour; $l_{i,j}^{m}$ – the distance between the the *i*-th settlement with the fire depot and the *j*-th settlements of the *m*-th UTH, km; l_{i}^{m}, l_{j}^{m} – respectively the distance of the longest part of the internal road network of the *i*-th settlement with the fire depot and *j*-th settlements in which the fire occurred on the territory of the *m*-th UTH, km; $k_{i,j}^{m}$ – the coefficient of road condition between the *i*-th and the *j*-th settlement at the territory of the *m*-th UTH; k_{i}^{m}, k_{j}^{m} – respectively the coefficients of road condition in the *i*-th settlement with fire depot and the *j*-th settlements in which the fire had started; $V_{\partial}, V_{н}$ – respectively the speed of the fire and rescue units amongst the settlements and on territory of settlements, km/hour; $V_{\partial b}, V_{нb}$ – respectively the speed of the fire and rescue units on the road parts with the damaged pavements amongst the settlements and on the territory of settlements, km/hour.

Having the quantitative value of the predicted number of fires in *j*-th settlements (n_{nj}^{m}) (3) and the model of the trip time of the fire and rescue units to the fire place on the territory of the *m*-th UTH (8), the matrix of levels of exposure to fire ($R_{нij}^{m}$) of *j*-th settlements in the *m*-th UTH is formed for various variants of the location of fire depots in the *i*-th settlements:

$$M_R^m = \left\{ R_{нij}^m \right\}, i = 1,n, j = 1,n, \quad (14)$$

where M_R^m – the matrix of levels of exposure to fire of *j*-th settlements at location of the fire depot in *i*-th settlements on the territory of *m*-th UTH, fire·hour; $R_{нij}^m$ – the level of exposure to fire of *j*-th settlements at location of the fire depot in *i*-th settlements on the territory of *m*-th UTH, fire·hour.

For each of the organizational variant of fire fighting systems development in the UTH (with k -th type of fire depot) the quantitative value of $R_{нij}^{mk}$ levels of exposure to fire of *j*-th settlements for the location of fire depots in *i*-th settlements on the territory of *m*-th UTH are determined by the formula (1). On the basis of the use of quantitative data of the (14) matrix, the ($R_{нi}^{mk}$) total level of exposure to fire of settlements was determined at location of k -th types of fire depots in each of the *i*-th settlements on the territory of the *m*-th UTH:

$$R_{нi}^{mk} = \sum_{j=1}^{n} R_{нij}^{mk}, \quad (15)$$

where $R_{нi}^{mk}$ – the total level of exposure to fire of the settlements at location of k -th types of fire depots in each of the *i*-th settlements on the territory of the *m*-th UTH, fire·hour; $R_{нij}^{mk}$ – the level of exposure to fire of *j*-th settlement for the location of k -th type of fire depots in the *i*-th settlement on the territory of the *m*-th UTH, fire·hour.

The information as to $R_{нi}^{mk}$ levels of exposure to fire of the *m*-th UTH at location of k -th types of fire depots in the *i*-th settlements is the base for its ranking and determining of the effective configuration of UTH fire fighting system in desirable condition. The finite number of configuration variants of the fire fighting systems of the *m*-th OTG in the desirable state is determined by the formula:

$$C^m = n \cdot n_k, \quad (16)$$

where n – the number of the settlements on territory of the the *m*-th UTH, unit; n_k – the number of the organizational variant for the development of UTH fire fighting systems (the k -th types of fire depot), unit.

Ranking of the *m*-th UTH fire fighting system in desirable condition at the predetermined its configuration gives the possibility to form the series in the order of increase of the $R_{нi}^{mk}$ level of exposure to fire of UTH settlements:

$$R_{н4}^{m3} < R_{н2}^{m2} < ... < R_{нi}^{mk}, \quad (17)$$

where $R_{нi}^{mk}$ – the total level of exposure to fire of the *m*-th UTH settlements at location of k -th types of fire depot in the *i*-th settlement, fire·hour.

Configuration ($K_{Sб}^e$) of the fire fighting system in the desirable condition of the *m*-th UTH is considered effective if it ensures the minimum level of exposure to fire of these UTH settlements:

$$K_{Sб}^{ef} = f\left(R_{нi}^{mk} \right) \to min. \quad (18)$$

Thus, the use of the proposed method of the configuration grounding of UTH fire fighting systems in the desirable condition allows to substantiate the effective type of fire station and the optimal place of its territorial location in the community as to the comprehensive criterion of exposure to fire of settlements with taking into account the configuration of the project environment (the number of inhabitants in settlements, the presence fire-hazardous objects and the characteristics of the network of roads in the territory of the UTH).

5. The results of grounding of the rational configuration the fire extinguishing system for the united territorial community

The rational configuration of the fire extinguishing system for the united territorial community is substantiated with the use of application software. The basis of the software is authors proposed method of coordination of the configuration of projects product for the development of fire extinguishing systems of the united territorial communities with the project environment. And also the basis of the software is the simulation of functioning of the UTH fire extinguishing systems in the desirable state. Functioning of the UTH fire fighting system is simulated for the conditions of Zhovtantsi UTH at the Kamianka-Buzka district of the Lviv region.

The rational configuration of the projects product for development of the fire extinguishing system of Zhovtantsi UTH was determined for the variant of the territorial location of the voluntary fire formation, which provides the minimum level of fire insecurity of UTH settlements. It is substantiated that for the conditions of Zhovtantsi UTH the voluntary fire formation should be located in the village of Kolodentsi.

In order to assess the cost of implementation of the Zvotantsi UTH fire extinguishing system, the existing and desirable fire extinguishing systems were compared. The existing extinguishing system is formed from the local fire brigade, which is located in the village of Velyke Kolodno. This system consists of 1 professional firefighter and 6 volunteers who use the AC-40 (131) 137 fire truck to extinguish the fire. The desirable fire extinguishing system of this UTH needs the creation of four types of the voluntary fire formation under the condition of construction of a new building. According to the option of fire brigade creating, it will be equipped with a Mitsubishi New L200 2.4 pickup with the Geyser MP-20/100P mobile complex. According to the option of creating a fire brigade it will be equipped with Tata LPT 613 + AC-18 fire truck. The composition of fire brigades of different categories is selected in accordance with current regulations of fire brigades formation in Ukraine.

On the basis of the appropriate calculations the histogram of the consolidated fund expenses is constructed under existing and desirable variants of a configuration of the Zvotantsi UTH fire extinguishing systems (Fig. 4).

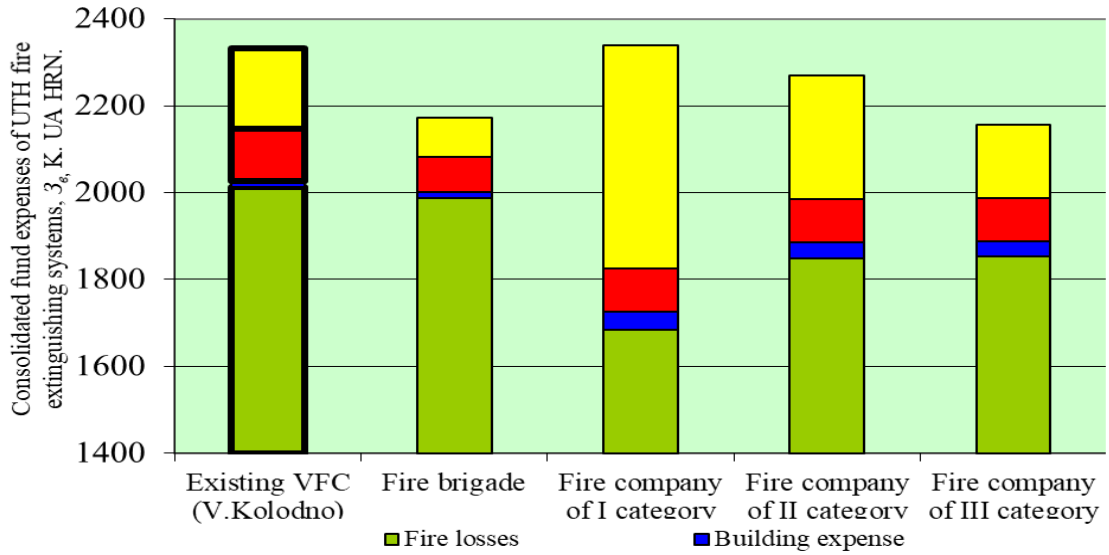

Figure 4: The histogram of the consolidated fund expenses is constructed under existing and desirable variants of a configuration of the Zvotantsi UTH fire extinguishing system

The research results (Fig. 4) indicate that in the structure of the consolidated costs of funds for the existing and desirable states of the Zvotantsi UTH fire extinguishing systems the greatest losses are from fires. The fire losses share for the creation of different types of fire extinguishing systems varies between 72… 91.5% and are the lowest for the fire brigades of the I category - 1685 thousand UAH, or 72%. It should be noted that the cost of firefighters and rescuers maintaining for different options of fire extinguishing systems creation varies significantly from 4.1 to 22%. The lowest costs for

keeping fire fighters are for variant of the fire brigades creation – 90 thousand UAH, and the highest – 513.6 thousand UAH are for the creation of fire brigades first category, due to the growth of the staff of fire fighters, who must be on duty around the clock at fire depots.

A small stake is occupied by the costs of maintenance of buildings and equipment, which varies between of 0.6… 1.7% and 3.7… 5.2%, respectively. At the same time, the lowest consolidated expenditures (2,155,725 thousand UAH) for the desired condition of the Zhovtantsi UTH fire extinguishing systems are in the scenario for the creation of a fire brigade of the III category in the village. At the same time, in such a scenario of development of Zhovtantsi UTH fire extinguishing systems it is possible to reduce the fire loses in this system by 158.58 thousand UAH, or 7.9% compared to the current situation.

The value of the implementation of the Zhovtantsi UTH fire extinguishing systems is defined as the difference between the consolidated costs of funds for the desirable and existing states of the fire extinguishing systems. Taking into account that the consolidated funds for the desirable state of the fire extinguishing system are variable and depend on the type of this system and the resources used in these systems, the value from the creation of fire extinguishing system will also be variable (Fig. 5).

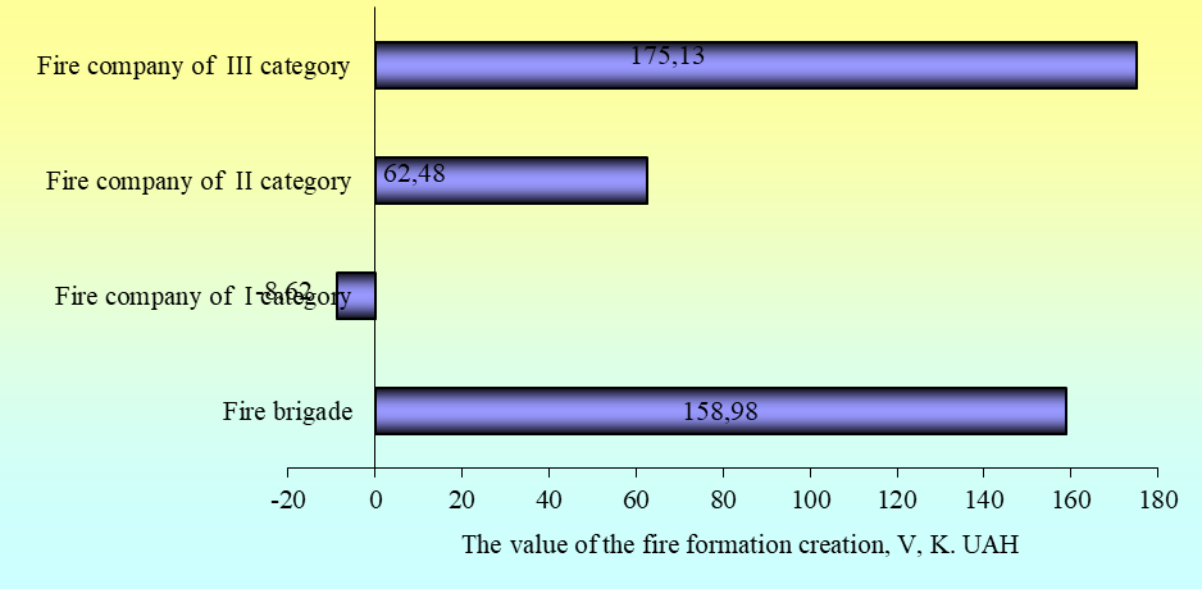

Figure 5: Trends in changes in the specific value (*V*) of PRSO of Zvotantsi UTH fire extinguishing system under different scenarios of their implementation

Based on the obtained data as to the *V* value of the implementation of the Zvotantsi UTH fire extinguishing systems, it can be stated that the maximum value (*V = 175.13 K. UA HRN per year*) is observed in the configuration of the Zhovtantsi UTH fire extinguishing systems with the creation of the fire brigade of III category.

The creation of such a fire extinguishing systems requires the construction of a fire station in the village of Kolodentsi, which will be equipped with a fire truck of Tata LPT 613 + AC-18 and should involve 3 fire dispatchers for round-the-clock duty at the depot. In addition, it is planned to involve 3 drivers and 6 firefighters who will perform their duties on a voluntary basis.

The substantiated rational configuration of the projects product of development of the UTH fire extinguishing system underlies forecasting both the resource expenses and risk during realization of the specified projects.

6. Conclusions

1. The analysis of the current state of the subject area, knowledge and practice of project management of the fire extinguishing system of rural areas in Ukraine made it possible to establish that this system has low effectiveness and needs the reengineering. The experience of the European Union and USA regarding the functioning of fire extinguishing systems in rural areas shows that for the effective protection of rural settlements, the voluntary fire brigades should be created at the

territory of the united territorial communities on the basis of the appropriate projects development of fire extinguishing systems.

2. The proposed method of configuration coordination of the products project for development of the fire extinguishing system of the united territorial communities with the project environment is based on the conceptual and simulation models of the desirable fire extinguishing system of the UTH. The effective type of fire station and its optimal location on the territory of the united territorial community are determined by the comprehensive criterion of exposure to fire of settlements, taking into account the changing configuration of the project environment (the number of inhabitants in settlements, the presence of fire hazard facilities and the characteristics of the roads network on the territory of UTH)

3. On the basis of the proposed method the cost indicators of functioning of a project product for development of fire extinguishing system of the united territorial community are defined at the various configuration bases. It is established that for the conditions of Zhovtantsi UTH the lowest consolidated fund expenses in the desirable state for the Zhovtantsi UTH fire extinguishing system are observed in the variant of the creation of the III category fire brigade in the village of Kolodentsi. The calculated cost was 2155.725 thousand UAH. This fire brigade should be equipped with a Tata LPT 613 + AC-18 fire truck and 3 fire dispatchers for round-the-clock duty at the depot, 3 drivers and 6 firefighters-rescuers who will perform their duties on a voluntary basis. The obtained results indicate the possibility to have the maximum specific value (*V = 175.13 K. UAH per year*) using a reasonable rational product configuration of the appropriate project.

4. Further research should be directed on the study of the impact of components of the changing project environment for the development of the extinguishing systems projects of united territorial communities with the grounding of the rational configuration on the cost of resources and risk for the implementation of these projects.

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