ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Determining The Number Of Staff To Eliminate The Results Of Emergency Situations Of Natural And Anthropogenic Origin In Rural Electrical Networks.

Alexey Valerevich Efanov[1]*, Sergey Vladimirovich Oskin[2], Sergey Sergeevich Yastrebov[1], Valeriy Georgievich Zhdanov[1], and Vitaly Nikolaevich Shemyakin[1].

[1]Stavropol State Agrarian University, Zootekhnicheskiy lane 12, Stavropol 355017, Russia.
[2]Kuban State Agrarian University named after I.T. Trubilin, Kalinina St., 13, Krasnodar 350044, Russia.

ABSTRACT

The paper investigates the possibility of using methods of queuing theory to determine the number of necessary repair personnel in rural electrical distribution networks to eliminate power outages caused by the impact of natural emergency situations. Calculation methods show that it is possible to use a multiphase queuing system with an infinite queue. As the initial data for calculations, the results of processing statistical data on the operation of electrical equipment for rural consumers' power supply systems are applied. As a result of calculations, the number of repair and operational teams will be determined, which must be recruited to eliminate the consequences of emergency situations for their elimination in a given period of time.
Keywords: staff team, technological violation, queuing system, failure flow parameter

Corresponding author

INTRODUCTION

Elimination of technological violations in power supply systems, especially related to power outages for consumers, should be made as quickly as possible in order to minimize damage to rural consumers from unplanned power outages. The magnitude of the damage depends on the type of agricultural consumers and applied production technologies and lies in the range from 130 to 3 rubles / kW • h of under-discharged electricity [1]. There are a number of regulatory documents for the elimination of technological violations (VT) in power supply systems, but we were not able to find in these documents how many personnel should be involved for this. This problem can be solved using the theory of queuing [2-5]. In practice, in the event of emergencies (natural disasters) of a natural nature, the elimination of VT can take quite a long time and is carried out by several brigades, so it is desirable to have information on the number of brigades involved in the elimination of VT.

The solution of this problem is possible with the use of multiphase queuing systems [6], while the liquidation of the VT is divided into several stages and each service stage is considered as its own QS, characterized by the input fault flow and the service time of the application. Obviously, not all applications fall to the next level of service, but only those that require more repair work. Thus, the use of the multiphase system of service allows you to determine the type and number of personnel involved.

When considering multiphase service, the same QMSs are applied at each phase. The used QMOs can be characterized as the following type $M/M/s:GD/\infty/\infty$ [5, 7]. That is, the incoming demand stream is Markovsky, with the parameter λ characterizing its intensity, the service flow of requirements is also Markovsky, respectively, with the parameter $\mu = 1/t_{rpc}$, the number of serving devices is unlimited, and, accordingly, is the desired parameter, type, unlimited; the number of failure sources is also unlimited.

The criterion for optimality of liquidation of the TN will be the service time, which should not exceed by more than 30% the elimination time of the TN during normal operation of the networks. The next phase is a smaller number of requirements - a certain part of the requirements (with a given probability is eliminated) when passing to the next phase. In this case, $\lambda_n = P_{fn} \bullet \lambda_{(n-1)}$ is the number of applications that passed from the phase $n-1$ to the phase n. The number of rejected applications $\lambda_{n-1}-\lambda_n = (1-P_{fn}) \bullet \lambda_{n-1}$. The applied multiphase QS can be represented as follows (Figure 1)

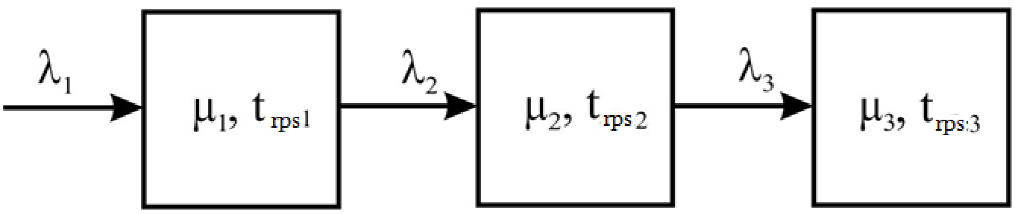


Figure 1: Example of considered multiphase QS

The first level is understood as the processing of applications for technological violations with the help of operational teams (OT) (λ_1, μ_1, t_{rpc1}), further, part of the applications with intensity λ_2 passes to the second phase, in which their service occurs in time t_{rpc2}. This phase describes the performance of repair work with the involvement of staff teams (ST), (λ_2, μ_2, t_{rpc2}). The third phase is also the processing of requests for OT, but after the repair by the forces of the involved OT (λ_3, μ_3, t_{rpc3}). It should be noted that applications that go to a lower level in the general case are not sifted Markov flow, since in this case they will represent the flows of Erlanga of the second order and higher. It is quite possible that two or more consecutive applications will require processing by all phases, so we assume that the input flow of each phase of the QS will be just the simplest Markovsky.

Another assumption is that the system is considered in a steady state, which, according to [8], occurs in a time of the order of $t \geq 3/\mu$. At the same time, the standard time for elimination of VT for most agricultural consumers is no more than 24 hours, which allows us to make an assumption about the stationary of the QS phases under consideration.

The input data for a multiphase QS can be obtained from the statistical data on the failure of power supply system equipment, which is obtained from [9], and the data of the acts of investigating technological violations (ARTN). ARTN contains information on the emerged VT: the duration of the accident, the causes of the incidents, the volume of disconnected consumers, damaged equipment, etc. The analysis was carried out for the period from 2001 to 2011 using the ARTN of one agricultural area of electric networks, its results are shown in Figure 2.

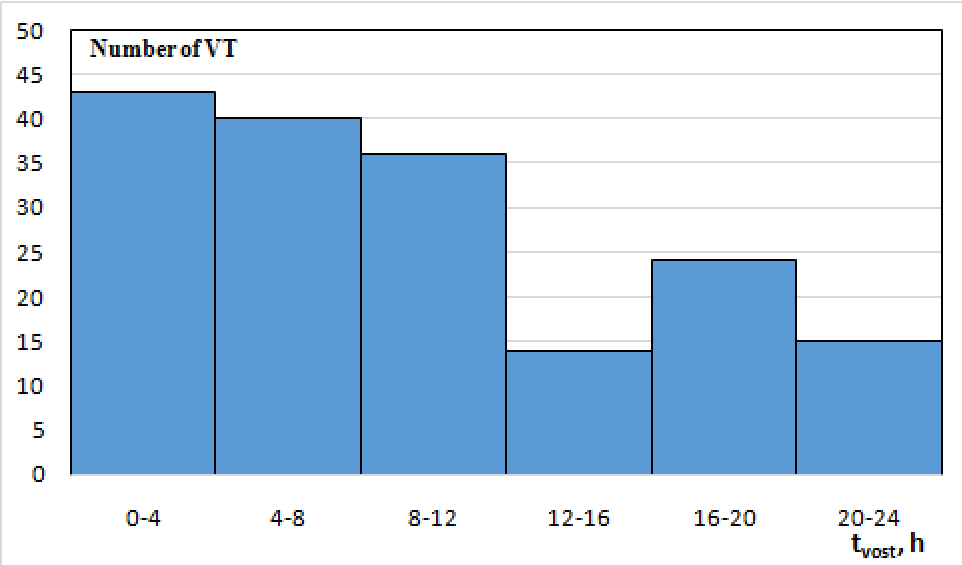


Figure 2: Distribution of VT by duration in the case of natural disasters

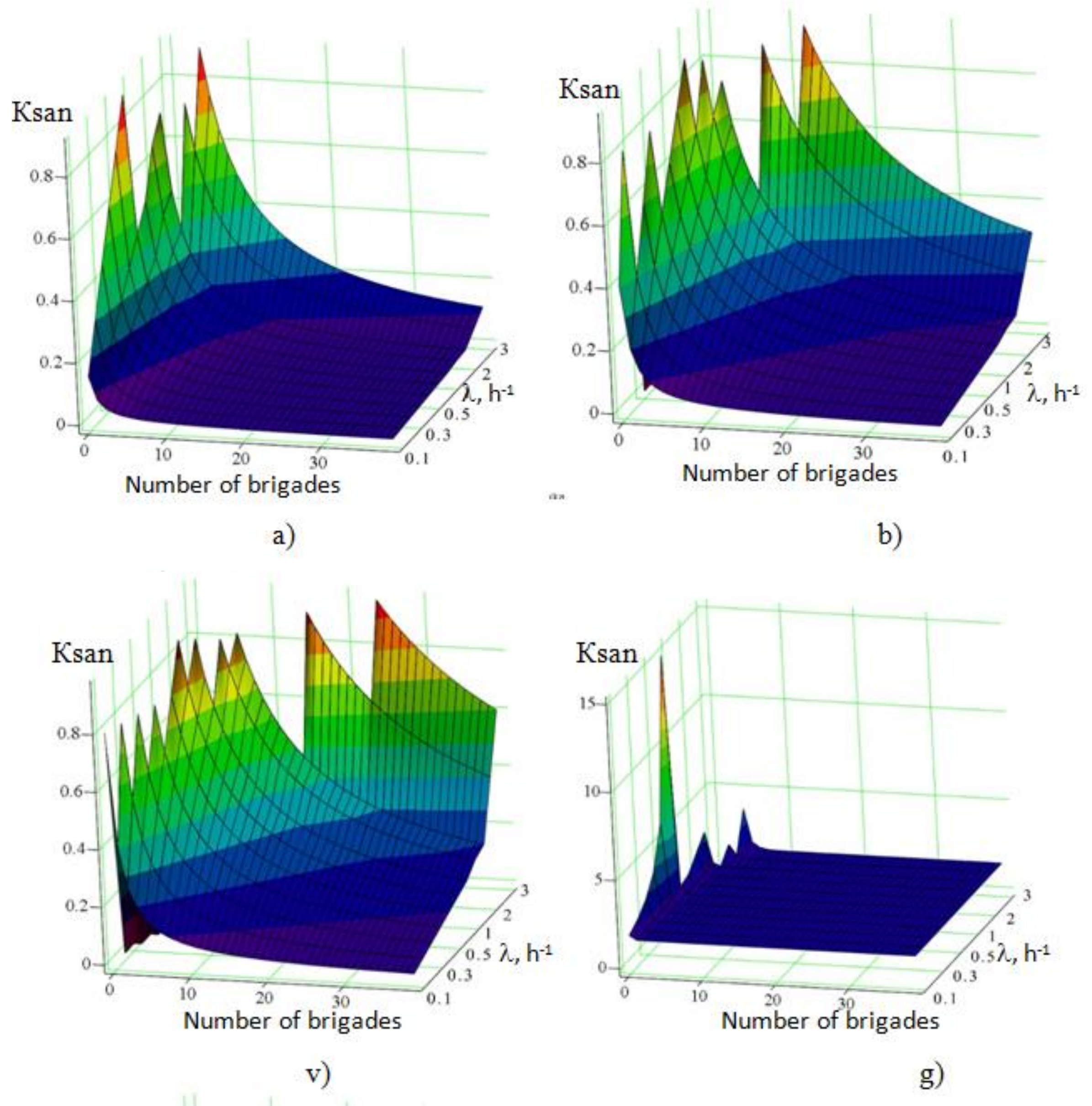
To obtain the distribution shown in Figure 2, information is analyzed about 10,000 ARTN. The analysis also established that the main cause of TN in natural disasters in the electric networks under consideration is a strong wind accompanied by either a thunderstorm with rain (in the summer) or by an intense ice formation on the wires (in winter). A fragment of the results of the VT analysis for emergencies is shown in Table 1.

Table 1: The result of the VT analysis of natural disasters

Act no.	Number of failures	Period of occurrence, h	Data
48(152)	5	1,97	15.02.2004
102(306)	2	6,62	27.02.2001
87(561)	20	2,12	29.08.2006
36(1298)	10	18,03	03.03.2005
9(2509)	21	23,92	14.02.2010
16(2516)	20	7,83	10.03.2010

It can be seen from Table 1 that when a natural disaster occurs, a large number of TNs is observed. At the same time, the time for liquidation of TNs by the forces of AXB can be taken as the largest average in the area of electrical networks, obtained by analyzing the data [5] - about 4 hours. Based on the model of multiphase SMO, it can be assumed that part of the HVAC OVB is eliminated on its own (the first interval is 0-4 h in Figure 2), or 25% (43 failures), and the remaining 75% of HVs fall into the second and third phases of the HFA (129 failures). In this case, the second and third phases are the liquidation of the TN by the forces of the Republic of Bashkortostan (we take the average recovery time as 8 hours) and the completion of the service maintenance for the repair work by the ATS (take the time at this stage equal to 1.5 hours).

The results of the calculations for one phase of the SMO are shown in Figure 3. At the same time, the failure flow parameter varied from 0.1 to 3; the number of teams in the calculations varied from 1 to 40. The schedules were obtained for different values of the service time of the applications.



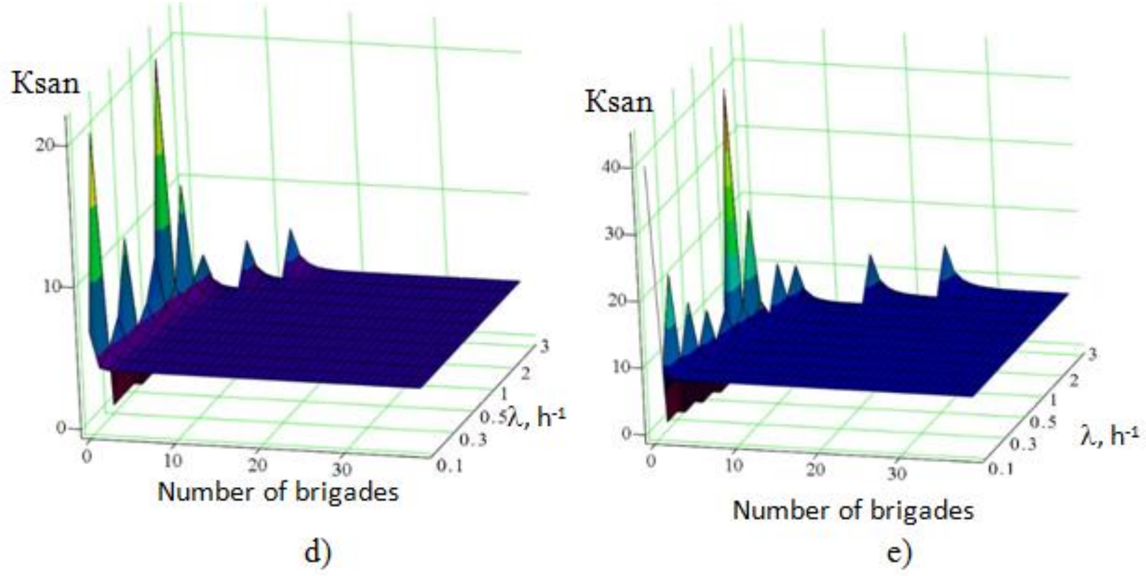


Figure 3: Results of the calculations of one phase of the QS: a), b), v) - the employment rate of the brigades; g), d), e) the average time of finding the application in the system. a), b) were obtained for T_{obs} = 1.5 h; v), g) for T_{obc} = 4 hours; d), e) for T_{obc} = 8 hours.

Using the parameters obtained within the framework of the multi-phase QS model, the results were obtained for the number of ATS and repair crews required for the elimination of natural disaster consequences. The parameters used and the results of calculations are shown in Table 2.

Table 2: Calculation of multiphase QS for averaging the flow of failures

Number of brigades	PHASE 1, T_{obs}=4 ч, λ1=0,4			PHASE 2, T_{obs}=8 ч, λ2=0,75·λ1			PHASE 3, T_{obs}=1,5ч, λ2= λ3		
	K_{san}	P_{ocher}	T_{sist}, h	K_{san}	P_{ocher}	t_{sist}, h	K_{san}	P_{ocher}	t_{sist}, h
1	0	0	0	0	0	0	0,45	0,20	2,73
2	0,80	0,57	11,11	0	0	0	0,23	0,02	1,58
3	0,53	0,15	4,78	0,80	0,52	16,63	0,15	0,00	1,51
4	0,40	0,04	4,15	0,60	0,17	9,44	0,11	0,00	1,50
5	0,32	0,01	4,03	0,48	0,05	8,35	0,09	0,00	1,50

In table 2 the following designations are accepted: K_{san} - employment ratio; R_{ocher} - probability of queue formation; t_{sist} - average time of the application in the system. In the calculations, formulas were used for the final probabilities of the SMO states [3], which can be applied under the condition that the queue does not grow to infinity, i.e. at $\lambda / \mu < n$, where *n* is the number of brigades. If there are zeroes in the cells of table 3, then this condition is not fulfilled. Calculations were carried out under the condition of averaging the flow of failures entering a multiphase SMO during a period of $3T_{obs}$ of the most prolonged phase of the QS-service request RB $3T_{ops}$ = 24 hours. For example, calculations were carried out for Act No. 36 (1298) from Table 1.

As can be seen from Table 2 (dedicated cells), with the accepted criteria for the effectiveness of VT liquidation, it is necessary to have teams: the first phase - 3 brigades, the second phase - 4 brigades and the third phase - 2 brigades, total: five operational teams and four repair brigades. At the same time, the average time to eliminate a technological violation is:

$$T_{vost} = t_{sist1} + t_{sist2+} t_{sist3} = 4,78+9,44+1,58 = 15,8 \text{ hours}.$$

ISSN: 0975-8585

CONCLUSION

Thus, the use of multiphase SMO is possible to determine the number of operational teams and repair teams to eliminate technological violations in emergency situations of a natural nature. At the same time, to determine the input parameters for the SMO, it is necessary to use statistical data on the operation of the power supply system of the electric network area. It should be noted that the estimated number of required teams is greatly affected by the failure flow parameter, which depends both on the number of technological failures and the averaging period that is applied. So, for an emergency situation of a natural nature, similar to the one observed on March 3, 2005 (wet snow adherence to wires with wind up to 30 m / s) observed in rural networks of the Turkmen District of the Stavropol Territory, which resulted in 10 technological violations (averaging period parameter of the flow of failures 24 hours), to eliminate them, according to our calculations, it is necessary to involve 5 operational teams and 4 repair brigades.

REFERENCES

[1] Vodyanikov V.T. Economic evaluation of the energy industry. Moscow: "IKF EKMOS", 2002.

[2] Oskin S.V. Probabilistic models of energy audit organization when working with enterprises of the agro-industrial complex. Mechanization and electrification of agriculture. 2013. 6. 27-29.

[3] Os'kin S.V., Gromyko D.V. Mathematical models of energy audit organization when working with agricultural enterprises. Proceedings of Kuban State Agrarian University. 2013. 42. 156-164.

[4] Oskin S.V., Gromyko D.V. the use of models of queuing systems for energy audits. In: Technical and technological systems. V International Scientific and Practical Conference. 2013. 199-203.

[5] Gnedenko B.V., Kovalenko I. Introduction to the theory of queuing. - 2 nd ed., Pererab. and additional. Science. 1987. 336.

[6] Grachev V.V., Moiseev A.N., Nazarov A.A., Yampolsky V.Z. Multiphase queuing model of the distributed data processing system. Reports of TUSUR, No. 2(26), part 2, December 2012. 248-251.

[7] Ventzel E.S. Investigation of operations. Tasks, principles, methodology. Moscow: Nauka, 1988. 208.

[8] Tarantsev A.A. "Investigation of transient processes in queuing systems with queues," in: Proc. "Harmonic analysis on groups", Moscow: MGOPU 1998, 40.

[9] IDGC of the North Caucasus. Information on emergency restrictions of PJSC "IDGC of the North Caucasus"