METHODS IN OPERATIONAL TRANSMISSION POWER GRID

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Abstract: The paper present the methods propose by the authors to be applied in operating of the substations. The substations take in consideration was rehabilitates by replace the existing equipments to new equipments made in the last generation. The substations take in consideration, also are change there architecture itself. The methods for the implementation of new equipments are issue. The technical difficulty in operational power grid and there resolution is present. The rehabilitated substations require new methods to complete the operational substations tasks. The method expose are the operational reliability. The mathematic methods and new analyses methods for resolve the operational substations tasks are issue. The analysis methods take in consideration the operational reliability, the technical parameters of equipments and those variations in operation, the importance of the equipments parameters, the statistics and the reliability and the specific parameters. The behavior of the equipments all over the operation time is analysis and was giving the solution for the future operation. The result of this research is use in the several applications. The local example for this application on a substation is issue. The elasticity of several type of the system architecture is analyzed. In the paper is answer the question how opportune is to make live maintenance to high voltage equipments.

Key words: Operational methods, Power

1. INTRODUCTION

The high voltage power networks, operating activities undergoing a transition from equipment and systems whose life is exhausted in new equipment and systems.

Mining activity is booming and follows a Quality Plan, which is a modern policy of quality, environmental protection and operational safety and health.

As part of the application of probability theory is still operating at the beginning, is hardly applicable due to small number of technical information that can be collected from the network. By upgrading facilities to start a new period, this will build new technical databases. Such databases will be created for new equipment will be useful only if they are created by a guide and will form the basis of applying the modern theory of probability.

In this context the authors propose a method of operation based on information provided by probability theory.

2. EQUIPMENT BEHAVIOR THROUGHOUT LIFE

Plant operation means all activities undertaken using the best conditions and the useful capacity of high voltage equipment, high voltage equipment tracking behavior and prevention of damage due to improper use, avoidance of high voltage equipment failures that could lose power system stability and security and a weakening carried.

Avoiding high-voltage equipment failure during operation is the target pursued within operating activities. This requires knowledge of parameters affecting the operation of the equipment. Only partial knowledge of the technical parameters of high voltage equipment operated resulting in the need to estimate their evolution, their use more efficient and better operating activities. These estimates can be made using indicators of probability.

Analyzes the records of accidental events in plants has been observed that these events have multiple causes. Thus the authors have classified these cases the following criteria:

- Works with that equipment
- Before its entry into service
- Was in operation during the normal life of equipment
- In service after the normal life of equipment
- Found in the reserve
- Operating times and seasons of the year with events
- Type of error committed
- Human error - User error
- Technical error - defective equipment
- Technical error - misuse the power grid
- Technical error - error maintenance

Activities affecting equipment were divided on stage investment. From analysis of the incident made the authors found that the causes of incidents can be classified as the period in which the error occurred, intervals that exactly suited investment stages. Investment stages we defined as:

a) The request - is initially, the intention of making an investment

b) The market - is leaving the market with investment, auctions

c) The design - the design phase is

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d) The production - the stage production is designed equipment
e) The assembly - assembly equipment is used instead of
c) The operation - is using a network equipment
g) The maintenance and repairs - performing maintenance on equipment

3. THEORETICAL BASIS USED TO ANALYZE EVENTS

During operation, the data acquired the equipment in service think that can be used to estimate the events. The authors were able to calculate:
- Probability of good functioning of equipment
- Probability of failure of equipment
- Probability of an operation or failure
- The probability of providing power to all consumers or energy requirement
- Frequency of equipment failure
- The probability of rapid and selective elimination of a defect
- The probability of making revisions to a minimum delay
- Intensity of damage
- Failure intensity

Probability calculations we have done with the following distribution functions:

- Exponential
-

$$E = 1 - e^{-\lambda x} \qquad (1)$$

- Weibull

$$W = 1 - e^{-\left(\frac{x-\gamma}{\eta}\right)^{\beta}} \qquad (2)$$

We recommend that the choice of distribution functions to be made by each user and the functions chosen by the authors are not strict. Choice of distribution functions in an analysis depends on the type of analysis, equipment analysis and variation in time of incident.

4. RESULTS

The method was considered accidental events occurring in an electrical network for a period of 5 years and a volume of 206 plants.

Table 1. Number of events analyzed plants

Time	Events							Number of plants
	OHL			Substations				
	total	AR	fails	total	primary system fails	secondary system fails	small problems	
5 years	717	629	88	4582	512	584	2486	206

In table 1 we show the number of events analyzed plants. Table 2 show the deviation from the ideal equipment and table 3 show the deviation from the ideal equipment on stage.

Table 2. Deviation from the ideal equipment

Equipment	Total life cycle
Circuit breakers	0,390
Disconnectors	0,372
Current transformers	0,378
Voltage transformers	0,373
Power transformers	0,410
Secondary systems	0,450
OHL	0,420

The graphics result from the table 3 are show in figure 1, 2, 3 and 4.
Base on these results we calculate the behavior of systems.

Table 3. Deviation from the ideal equipment on stage

Plants	The request	The market	The design	The production	The assembly	The operation	total
OHL	0,05	0,10	0,14	0,08	0,09	0,42	0,88
Substations	0,07	0,08	0,08	0,08	0,05	0,40	0,76

Secondary systems (SCPA)	Power transformers
0,11	0,07
0,04	0,12
0,15	0,08
0,11	0,09
0,05	0,05
0,45	0,41
0,91	0,82

During the operational time service of the equipment, several failures were experienced, having different causes, as:

- data error - missing data, insufficient data or wrong data about the equipments (location, technical issue, fitting, operational and maintenance, quality, maintenance paper, other maintenance or operational service paper from Quality Plan, environmental plan, geological plan, other data etc.),

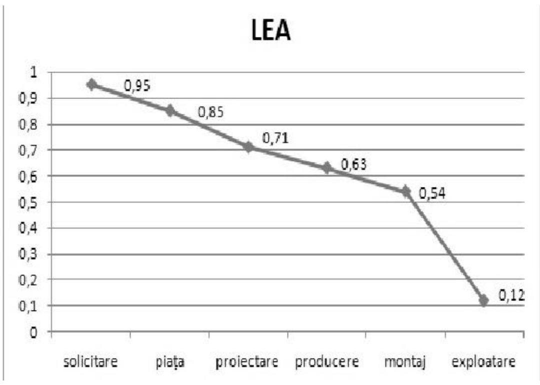

Fig. 1. OHL evolution on live cycle

- setting error - data error about place, equipment parameters, error - communication, error – demand etc,
- fitting error,
- operational error (overload, wrong maneuver, external cause, natural phenomenon, human error, planning error).

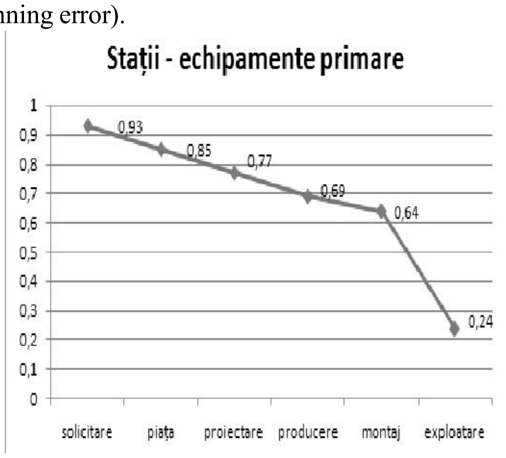

Fig. 2. Primary equipments from substations evolution on live cycle

The difference between the owner demand and the necessities and equipment acquisitioned appeared in demand and/or marketing steps.

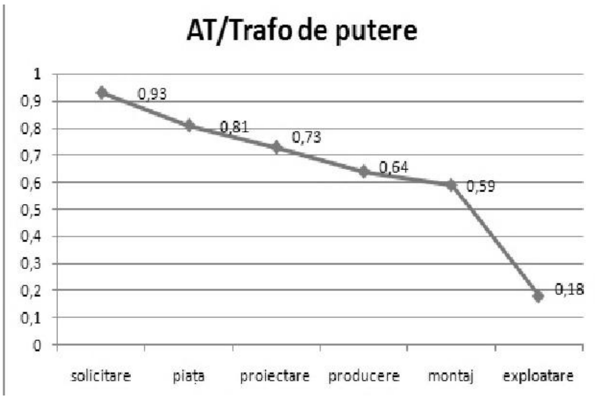

Fig. 3. Transformers and autotransformers units' evolution on live cycle

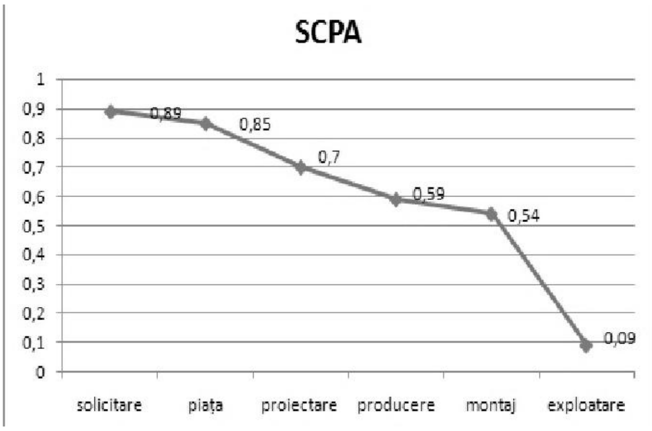

Fig. 4. Secondary systems fron substation evolution on live cycle

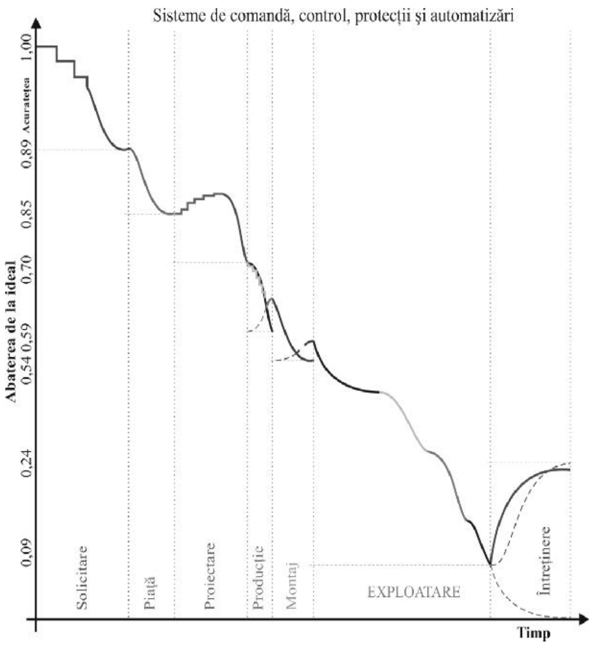

Fig. 5. Deviation for secondary systems in time

This error has the following causes:

- demand, containing parameters which can't be come true;
- demand (different) as needed by the substation;
- demand – incomplete;

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- missing that very type of equipment on the market;
- economic, unfavorable situation.

The probability to appear failures must be known by the personnel of decision, in order to further improve the methods to be applied into the operational substation. Failure can appear during the operation of the substations and, the need for estimation is related with:

- the break of the equipment,
- lose the load,
- late and non selective eliminated failures,
- breaker failure action,
- long time for maintenance,
- lost the auxiliary transformer or bus bar without the self-start Diesel generator,
- AR or break the OHL,
- wrong actions of the equipment

The equipment behavior under detailed analyses, was derived by using standard calculus for the operational reliability affected to a substation, seen as a system with different schemes and types of architecture.

We did study how can be used the equipment in several type of architecture of the system, safer and economically.

The study indicates which type of system architectures are the most profitably, from both points – safety and economic.

The data from the operational reliability calculus of the equipments, which was presented above, was used to calculate the reliability of the system (equipment gathered into the substation). We have taken into consideration the behavior of the system in relation to each kind of failure.

The conclusions of the analysis on the system's types are:

- can't function for long time with the equipment on the by-pass bus bar,
- the grater reliability of a system belongs to the followings:
- 1.5 circuit breaker type,
- double bus bar type,
- hexagonal type.

For the installations reliability estimation (OHL, bay, power transformer, protection, auxiliaries services) were considered different system architectures.

Table 4. The Reliability of the Systems

No.	System type	Reliability, *R* (%)
1	simple bus bar - OHL - simple bus bar	0.36
2	simple bus bar - transformer - simple bus bar	0.34
3	double bus bar - OHL - double bus bar	0.41
4	double bus bar - transformer - double bus bar	0.42
5	double bus bar with by-pass bus bar - OHL - double bus bar with by-pass bus bar	0.52
6	double bus bar with by-pass bus bar - transformer - double bus bar with by-pass bus bar	0.60
7	double bus bar - OHL - double bus bar with by-pass bus bar	0.45
8	double bus bar - transformer - double bus bar with by-pass bus bar	0.52
9	1.5 circuit breaker - OHL - 1.5 circuit breaker	0.41
10	1.5 circuit breaker - OHL - double bus bar	0.40
11	1.5 circuit breaker - transformer - 1.5 circuit breaker	0.44
12	1.5 circuit breaker - transformer - double bus bar with by-pass bus bar	0.45
13	hexagonal - OHL – hexagonal	0.39
14	hexagonal - OHL - 1.5 circuit breaker	0.40
15	hexagonal - transformer – hexagonal	0.40
16	hexagonal - transformer - double bus bar	0.38
17	"H" system - "H" system	0.10
18	"H" system - OHL - 1.5 circuit breaker	0.21

19	1.5 circuit breaker - "H" system - OHL - double bus bar	0.24
20	"H" system - cross function	0.38
21	"H" system - 2 OHL with 1 transformer	0.18
22	OHL in double bus bar with by-pass bus bar system in function on proper bay	0.84
23	OHL in double bus bar with by-pass bus bar system in function on by-pass bus bar	0.80
24	transformer in double bus bar with by-pass bus bar system in function on proper bay	0.84
25	transformer in double bus bar with by-pass bus bar system in function on by-pass bus bar	0.80
26	single bus bar – OHL	0.79
27	double bus bar – OHL	0.82
28	1.5 circuit breaker – OHL	0.83
30	hexagonal – OHL	0.81
31	OHL - transformer in "H" system	0.42

The assessment of the reliability of the systems we did consider the reliability of equipment in each hand, indicated also as the number of equipment failure. This information gives more insights when it is to compute as the deviation from ideal case and decrease the reliability in the operational time of the equipment, as seen in Table 4.
Among the most convenient substations' schemes system for reliable operation are "double bus-bar with by-pass bus bar - installations" - "double bus bar with by-pass bus bar" and "1.5 circuit breaker- installations - double bus bar with by-pass bus bar".
However, the most reliable system chosen, affordable also from the economic point of view into our country, proved to be that of "double bus-bar, 3/2 circuit breaker" - type.
Until the last year, this configuration was unique and was used only into the 400kV substation, devoted to the first Romanian nuclear power plant NPP Cernavodă, having great steam turbine-generator units, each rated 720MW, 24/400kV and 1500rpm.

5. CONCLUSION

As far as the reliability offered by the substations, the work was focused mainly over the great achievements, quite recently erected and putted into operation. Other schemes were also analyzed, but because there were not considered representative, none comment was given herewith.

In so doing, by comparing a lot of schemes, the results of the behavior of different systems over 5 years of operation are present into one condensed form shown.
The second large substation in our country, refurbished at Sibiu Sud with the levels 20kV, 110kV, 220kV and 400kV; at the highest voltage levels, this substation is a vital linking node between southern part and the mid country's generating power plants, responsible at some extent for the NPG stable operation, as a whole.
This selection stands also as a great achievement in the field we have already discussed above in this paper and does underline the conclusion of our study as being correct, sustained by the calculations given, which could be found into one condensed presentation

REFERENCES

[1]. NPG Transelectrica-SA, Raport anual, NPG Transelectrica-SA, pp. 15-19, Dec. 2009.
[2]. NPG Transelectrica-SA, *Raport anual*, NPG Transelectrica-SA, pp. 15-19, Dec. 2008.
[3]. I. Felea, N. Cheroiu *Fiabilitatea şi mentenanţa echipamentelor electrice* Oradea University Publishing House, 2001, p. 21-50.
[4]. I. Felea, *Ingineria fiabilităţii în electroenergetică. Bucharest* Didactic and Pedagogic Publishing House, 1996, p. 15-150.
[5]. A. Leca and co-authors, *Principii de management energetic* ET – Bucharest Technical Publishing House, 1997, p. 15-250.
[6]. .SC Tehnorob, *Estimarea duratei de viaţă a LEA 220-400kV din gestiunea ST Sibiu*, SC Tehnorob, Bucharest, Tech. Rep.C12, Nov. 2007.
[7]. D. Morar and B.D. Guzun, *Optimum Methods for Power Grid's Operation*, presented at the International World Energy System Conference - WESC, The Politehnica University from Iaşi, Romania, July 2008.
[8]. D. Morar, *Retehnologizarea staţiilor de înaltă tensiune*, Ph.D. dissertation, The Politehnica University from Bucharest - PUB, The Faculty of Power Engineering, Power Generation & Use Chair Dept. Bucharest, 2003.
[9]. D. Morar, *Sisteme de protecţii pentru staţiile de înaltă tensiune*, Ph.D. dissertation, The Politehnica University from Bucharest - PUB, The Faculty of Power Engineering, Power Generation & Use Chair Dept. , 2004.
[10]. D. Morar, *Metode de optimizare a exploatării staţiilor de înaltă tensiune*, Ph.D. dissertation, The Politehnica University from Bucharest - PUB, The Faculty of Power Engineering, Power Generation & Use Chair Dept. Bucharest, 2007.

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