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HIGH AND MEDIUM VOLTAGE OVERHEAD LINES REVITALISATION

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ABSTRACT

In the F.R. Yugoslavia a great number of elderly overhead lines (OHL) are in operation, so that the international community invests a significant amount of money for their revitalization. The most important issue is adequate allocation of money to those OHLs that have the greatest impact on power system (PWRS) reliability and that are in the emergency for revitalization activities.

The purpose of this article is to present the methodology and software for objective quantification of an OHL status, that is, to give its current availability level, significance (in the sense of PWRS operation) and to estimate the residual life period. The outcome of the software is the sequence and the amount the planned revitalization activities, obtained by using the optimization of OHL technical characteristics within the available capital funds.

In first stage, numerical estimation of the OHL availability levels and establishment of the broader list of OHL potential candidates for revitalization is performed.The definitive priority list of the OHLs that are the most important revitalization candidates is built by using the laboratory measurements of a number of technical characteristics of those OHL that are estimated as potential candidates in the previous stage.

Because of the huge number of data, which is needed for this methodology, and since the great number of criterions should be taken into account the authors have developed the software tool "Revitalization Tools". It offers the opportunity of equitable, technically reasonable approach to ranking the OHLs that are supposed for revitalization. Besides, this software gives the suggestions for the set of activities that need to be donned during the revitalization procedure of each OHL precociously selected. The time schedule of all revitalization activities is also presented to the user. Here, the special attention is paid to the time period in which new equipment should be provided.

1. INTRODUCTION

After period of time of great investing into network development and construction of new OHL, comes period of investing into revitalization of existing networks, first of all investing into not very young OHL.

In last years has appeared a need for revitalization of OHL, i.e. for making a methodology which will perceive this problem in its complete complexity. Overhead lines revitalization includes a set of measurements that have to be undertaken on the existing overhead lines in order to prolong its exploitation age. Expected exploitation age of electrical equipment (conductors, insulators, connection equipment) is around 40 years while the age of columns and foundations is esteemed to over 80 years. It is justified to apply a revitalization procedure which will replace the electrical equipment, depending on its state at the moment, by a modem one. In that way are avoided larg investments for a new OHL and a property-legal problems for forming a new corridor. Besides that are replaced old protective ropes by new ones with optical cables by what OHL gets also quite new function, and it is a transfer of information. In such a case a problem is posed to harmonize order to perform revitalization with on urgency state of replacing need.

Since changes in our power systemic (PWRS) due to high investment cost practically are out of question, it is very probable that overhead lines, even those that are in bad condition, would be seen as unreplacement factors of work of PWRS and distributive systems. In such a situation, capital investments into revitalization are variable. Revitalization is a great set of activities which are not traditional part of OHL planned maintenance.

There is a need for making a unique methodology and corresponding software tools for estimation of OHLs state and odder of their revitalization. Data have been collected for decades and their variety by kind and manner of achievement, as well as their enormous number, impose a nee for a unique methodology and software tool. Software tool is necessary in order to make possible considering the greatest possible number of statistical data, and then data obtained by investigation as well as by field measuring and one in laboratories. By respecting these data the objective state picture of observed overhead lines is obtained. Exists a nee for a unique methodology that can be applied for each overhead line individually. In that manner the analysis results of all OHLs in network are mutually comparable. The questions to what such methodology and software are expected to answer are: whether and when to undertake activities to improve characteristics of OHLs in drive, when to start detailed analysis, exploitation age till application of concrete measures, which equipment to be changed-revitalized, what are characteristics of the equipment, pri-measuring and preliminary costs as well as financial benefits. This methodology and software tool can find application in electro-distributive and transfer utility enterprises.

2. OVERHEAD LINES REVITALISATION PROCEDURE

Overhead lines revitalization includes a set of measurements that should be undertaken on existing overhead lines in order to prolong its

exploitation age, i.e. to makes possible that the given overhead line during in advance determined period can normally perform its function:

- Revitalization of constructions ruction equipment (poles and/or foundations) includes certain works on poles and/or foundations, if it is techno-economically justified, in order to prolong the exploitation age of that equipment, and by that also of overhead line as a whole;
- Revitalization of electrical equipment (conductor and/or connection equipment and/or insulators and/or protective cables) includes replacement of existing by a new one;

Application of optical cables in protective cables by this partially to some extent is changed the OHL purpose. Namely, besides to energy transfer, by application of optical cables, the data transfer is also made possible. This data transfer has a fundamental importance for qualitative and reliable work of power system but it also can be used for public uses.

3. REVITALISATION DECISION-MAKING

The methodology is described in Figure 1. The most importance activities are divided in 7 steps and their role will be described later.

In FR of Yugoslavia is used a great number of older overhead lines, so that it is necessary to invest a considerable amount of money into their revitalization. The most important task is an adequate allocation of money onto those OHLs which have the greatest influence upon reliability of PWRS and which are in such a state that they require revitalization.

The purpose of this paper is to present methodology and software for qualification of OHL state, while primarily importance of OHL from the point of view of reliability. Advantages of the proposed methodology are:

All overhead lines have been analyzed in the same manner. Their levels of availability are described numerically, which makes possible the comparison of overhead line state.

- As a result of the proposed methodology for revitalization, the modernized OHL can be obtained able to work in the following 40 years. So revitalized overhead lines have enlarged reliability and nominal current.
- Capital costs are only 40-60% for a new OHL, but operational costs and costs for undelivered energy are significantly reduced in relation to the state before revitalization.

Procedure consists of a set of steps:

1. Acquisition of data which represent a history of events during OHL exploitation.
2. Owner of OHL defines vector of limit values, i.e. criteria on which basis is determined OHL which is a candidate for revitalization (COHL).
3. Basic data include also data on configuration of lines and data on consumer's characteristics.
4. OHL state estimation. This procedure consists of four basic steps.

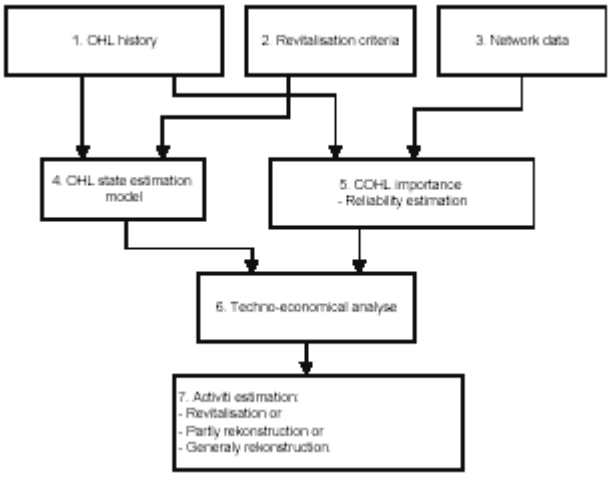

FIGURE 1. SIMPLIFIED BLOCK DIAGRAM OF METHODOLOGY OF OHL SELECTION FOR REVITALIZATION

4.1. Failure statistical analysis on OHL and estimation of COHL. COHLs are those OHLs in which in exploitation history has been evident increased number of failures and other events. Statistical investigation of OHL failures data can indicate to OHL state but also to failures causes. In this paper will be presented only a part of visual presentations of statistical analyses. Thus analysis of a mean number of failures by months, during a year, indicate that a dominant number of failures occur in summer months. If it is known that in summer months occur days with atmospheric discharges which can lead to breakthrough of insulators it is clear that OHL revitalization should contain also strengthening of insulators and building in of protective cables as a measurement for defense from direct thunderbolt.

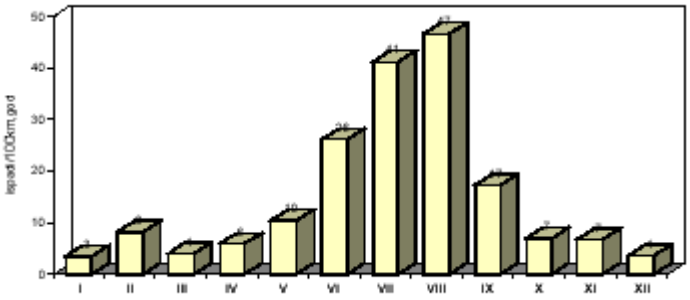

FIGURE 2. 1 10KV OHL FAILURES BY MONTHS

The following diagram by which is described distribution of a mean number of failures per hour during a day point to an increased failure number during night hours. Especially is evident increased number of failure numbers in early morning hours, from 4 to 5 o'clock a.m. Namely, in colder, night time insulators get moist by condensed water (dew) and then occurred jumpiest over insulators' surface. That is a reason why insulators are replaced and so that new ones have prolonged their so-called current path route.

On a certain number of OHLs has been built-in protective thunderbolt cable and that brought to considerable improvement of reliability in work of OHLs on which the revitalization has been done

with mentioned improvements. In the lower diagram it is seen that installation of protective conductors cut into halves the mean annual failure number.

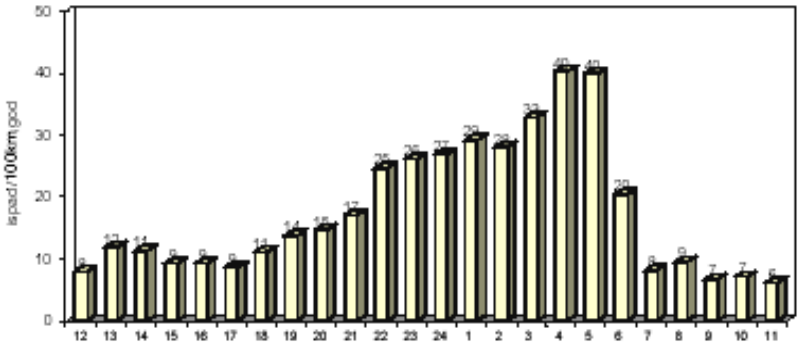

FIGURE 3. 11 0KV OHL FAILURES PER HOUR DURING A DAY

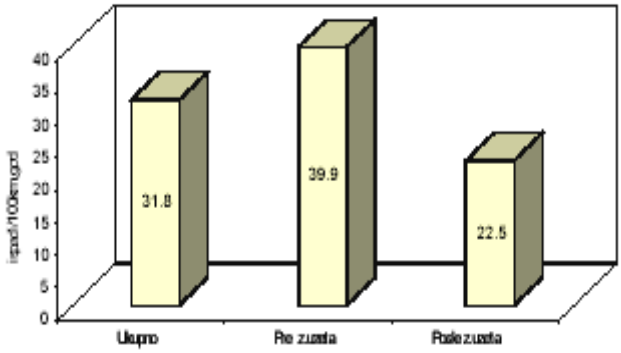

FIGURE 4. 110 KVOHL DISORDERS BEFORE AND AFTER INSTALLATION OF PROTECTIVE ROPECONDUCTOR

4.2. OHLs age

4.3. State check in the field. Experts team by visiting COHL estimates state and takes samples of COHL for laboratory investigation if it is needed. In developed electrical utilities also is being used OHL supervision in the field by air-photo-shooting by digital cameras. Shooting is being done in two flies of the plane, per once from both OHL directions. These shots later can be analyzed in offices displayed on a computer. Digital shots make possible easy zooming of susceptible details on OHL and by that considerably is decreased price of OHLs inspection in the field.

4.4. Laboratory investigation of samples brought from the field and bringing a definitive conclusion whether it a candidate.

5. Estimation of each COHL individually. By application of the software tool for reliability analysis is estimated annual undelivered energy or damages due to failure. For revitalization the most important is OHL which has the greatest annually undelivered energy or annual damage cost due to failure in supply of consumers.
6. Techno-economical analysis serves for determination of scope and kind of needed works on OHL depending on the previously perceived state. In techno-economical analysis are respected price of the equipment that is built in, cost of mount and dismount works during revitalization, price of measuring of equipment characteristics, savings for maintenance costs and loss decrease due to energy transfer, savings for

damages that consumers suffer due to undelivered energy during exploitation failure, savings caused by postponing of investments and remained value of dismounted equipment.

Possible variants of activities which have to be undertake: reconstruction, revitalization, rehabilitation, recovery and postponing of any kind of work. Basic criterion for selection of one of those variants is the previously perceived state, and through techno-economic analysis are compared costs for possible works and costs for maintenance and exploitation of OHL in the case that works are done or postponed. If the costs of preventive maintenance and revitalization are too high then OHL reconstruction is applied. In contrary is continued the analysis of measures for improvement of OHL state.

4. CONCLUSION

After a time period of great investments in network development and OHL building, comes the time period of revitalization of present networks, before all investments into not so new overhead lines (OHL). The huge quantity of parts of overhead networks built long time ago required, at due time, huge investments into their construction. And now, they require the significant investments into their revitalization. The investment costs are very high and therefore have to have the objective review of justified money spending. The big money fund management, for OHL maintenance, needs the sophisticated approach and respect the big set of data and technical knowledge, important for proper review of decisions.

Because of the huge number of data, which is needed for this methodology, and since the great number of criterion should be taken into account the authors have developed the software tool "OHL Revitalization Tools"? It offers the opportunity of equitable, technically reasonable approach to ranking the OHLs that are supposed for revitalization. Besides, this software gives the suggestions for the set of activities that need to be donned during the revitalization procedure of each OHL precisely selected. The time schedule of all revitalization activities is also presented to the user.

REFERENCES

[1.] M. DUTINA, G. RADANOVIĆ, Z. SLIJEPCEVIĆ, Z. HRUBENJA, Overhead Lines Revitalization", III Conference SLOKO CIGRE, Nova Gorica, Jun 1997.

[2.] M. DUTINA, M. PAVLOVIĆ, "An Approach to Overhead Lines Revitalization", XXV Conference JUKO CIGRE, Herceg Novi, September 2001.

[3.] M. D. NIMRIHTER, "Comparative Analysis of Security Concepts for Urban Medium Voltage Distribution *Networks", Electric Power Research,* 29(1994.), pp.43-50.

[4.] M. D. NIMRIHTER, "Reliability Indices Estimation of Distribution Circuits by Application of Distribution Automation", *DA/DSMEUROPE 96,* Vienna, October 8-10, 1996, pp.547-558.

[5.] M. M. DUTINA, M. D. NIMRIHTER, "Overhead Lines Revitalisation-Methodology and Software Tools", *DistribuTECH Europe 2001 Conference,* Berlin, November 2001.