STRATEGIES REGARDING OPERATING VOLTAGE LEVELS IN DISTRIBUTION NETWORKS

Gheorghe GRIGORAS[1], Gheorghe CARTINA[2]

The power/energy losses reduction in distribution systems is an important issue during planning and operation, with important technical and economical implications. Thus, the energy losses minimization implies not only the technical improvement of the network, through its renewal with the introduction of the technological innovations in the equipment and circuit components as well as the optimal planning of the design and development of the network, but also requires the use of the methods and software tools to facilitate the operation process.
The paper presents a strategy for power/energy saving which replacement of the 6 kV voltage level with 20 kV voltage level. In this line, different urban distribution networks were analyzed using fuzzy techniques.

Keywords: power/energy saving, voltage levels, distribution networks, fuzzy techniques.

1. Introduction

The evaluation of power losses is very imported in establishing the proper measures for the reduction of these losses.

The minimization of energy losses in distribution networks is an important issue during planning and operation, with important technical and economical implications. The estimation of the power losses levels depends upon a number of parameters and variables that derive the design criteria and the operating conditions of the distribution networks. Thus, the feeders have a broad universe of the different variables, such as nominal voltage, the length, installed power of transformations, the number of the transformation points, the circuit type (underground, aerial, mixed), load being served etc [2], [5].

Even if a feeder has more power losses compared with other feeders, it does not imply that it is operating out of the normal condition. It may have more length, may be more loaded, may have more transformation points, etc, presenting different constructive or operative characteristics.

A policy for the reduction of losses can contain short and long term actions. The some short term measures are following:

[1] Lecturer, Technical University “Gh. Asachi” of Iasi, Romania
[2] Prof., Technical University “Gh. Asachi” of Iasi, Romania

- Identification of the weakest areas in distribution network and improve them;
- Reduction the length of the distribution feeders by relocation of distribution substation/ installations of additional transformers;
- Installation of shunt capacitors for improvement of power factor etc.

The some long term measures are following:

- Mapping of complete distribution feeders clearly depicting the various parameters such as nominal voltage, the length, installed transformation capacity, the number of the transformation points, the circuit type (underground, aerial, mixed), load being served etc.
- Replacement of the 6 kV or 10 kV voltage level with 20 kV voltage level;
- Compilation of data regarding existing loads, operations conditions, forecast of expected loads etc.
- Estimation of the financial requirements for implementation of the different phases of system improvement works.

The paper presents a strategy for power/energy saving which replacement of the 6 kV voltage level with 20 kV voltage level. In this line, different urban distribution networks were analyzed using fuzzy techniques.

2. Load modeling using fuzzy techniques

In distribution networks, except the usual measurements from substations, there are few information about the network state. The feeders and the loads are not usually monitored. As a result, there is a high degree of uncertainty about the power demand and, consequently, about the network loading, voltage level and power losses. Therefore, the fuzzy approach may reflect better the real behavior of a distribution network under various loading conditions, [3].

The fuzzy set theory was introduced to various system engineering problems in which uncertainties were represented as intrinsic ambiguities. In this paper, trapezoidal fuzzy numbers, Fig.1, associated to a membership function are used to represent a vague knowledge about the load behavior.

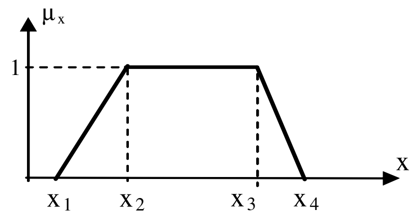

Fig.1. Trapezoidal fuzzy load

For modeling of the loads, two primary fuzzy variables are considered: the loading factor kI (%) and power factor cosφ, so that the fuzzy representation of the active and reactive powers result from relations, [3], [4]:

$$P = \frac{kI}{100} \cdot S_n \cdot \cos\varphi, \quad Q = P \cdot \tan\varphi \tag{1}$$

where S_n (kVA) is the nominal power of the distribution transformer from the distribution substations.

The fuzzy variables, kI and cosφ, are associated to trapezoidal membership function, Table 1. The two fuzzy variables must be correlated, just like that fuzzy variables P and cosφ.

Table 1

Linguistic categories of KI and cosφ

Linguistic Declaration		x KI [%]	x cosφ	Linguistic Declaration		x KI [%]	x cosφ
VS (Very Small)	x_1	10	0.75	M (Medium)	x_3	55	0.87
	x_2	10	0.77		x_4	65	0.89
	x_3	15	0.79	H (High)	x_1	55	0.87
	x_4	25	0.81		x_2	65	0.89
S (Small)	x_1	15	0.79		x_3	75	0.91
	x_2	25	0.81		x_4	85	0.93
	x_3	35	0.83	VH (Very High)	x_1	75	0.91
	x_4	45	0.85		x_2	85	0.93
M (Medium)	x_1	35	0.83		x_3	95	0.95
	x_2	45	0.85		x_4	95	0.97

The fuzzy load modeling (linguistic categories) was used in the steady-state calculus of the distribution networks for evaluation of the power losses.

3. Study Case

In the paper it was analyzed an urban distribution network of a 110/6 kV Power Station, with 8 feeders. The power losses for the considered power station are calculated for two variants:

- Case I - with voltage level by 6 kV;
- Case II - with voltage level by 20 kV (by replacement of the 6 kV voltage level with 20 kV voltage level).

The power losses (in percents), are presented in the Table 2. These were calculated for peak load regime that it records in system. The loading levels of the every feeder, in this regime, are indicated in the table. It can observe that the power losses in the cables at the 20 kV voltage level are lesser than in the cables at the 6 kV voltage level. For the power losses from the distribution transformers, these have approximate same values because the loading level is same in the both cases.

Table 2

The power losses of the feeders as function of the linguistic loading level, [%]

Loading Level	Case	ΔP_L [%]	ΔP_{Load}[%]	$\Delta P_{Non\text{-}load}$ [%]	ΔP_{Tr} [%]	ΔP_T [%]
VS	I	3.01	0.39	1.98	2.37	5.38
	II	0.26	0.39	2.06	2.45	2.71
S	I	9.86	0.83	1.01	1.83	11.70
	II	0.86	0.82	1.15	1.97	2.83
S	I	9.25	0.55	1.18	1.73	10.98
	II	0.82	0.55	1.33	1.88	2.70
H	I	0.06	0.07	0.09	0.15	0.22
	II	0.01	0.07	0.09	0.16	0.17
S	I	19.15	0.56	1.06	1.62	20.77
	II	1.77	0.55	1.38	1.94	3.71
VH	I	1.47	1.05	0.79	1.84	3.31
	II	0.13	1.05	0.80	1.85	1.98
VH	I	1.21	1.15	0.79	1.93	3.15
	II	0.09	1.15	0.80	1.95	2.03
M	I	0.53	0.67	1.29	1.96	2.49
	II	0.05	0.67	1.30	1.97	2.01
Total power losses	I	8.38	0.58	1.04	1.62	10.01
	II	0.76	0.58	1.18	1.76	2.52

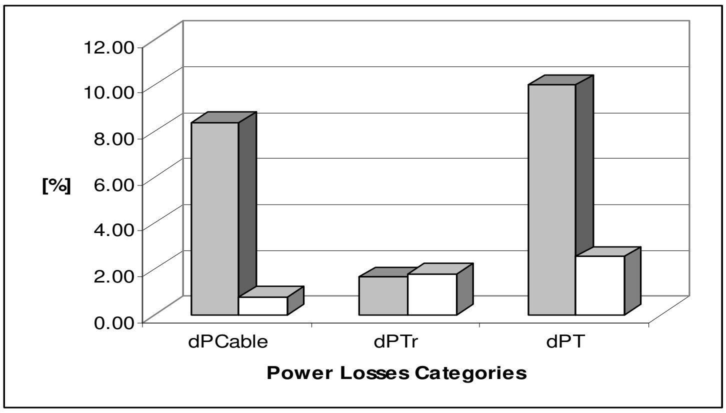

Fig. 2. Comparison of the power losses to 6 kV and 20 kV

For the considered case, from the Fig. 2 it can observe that the replacement of 6 kV voltage level with 20 kV voltage level represents an economic solution to decrease the power/energy losses and to enhance the reliability of distribution networks.

4. Conclusions

In distribution networks losses are relatively higher when transformers are lightly or heavily loaded. The paper shows that there is an important energy saving by old transformers replacement with efficient transformers.

REFERENCES

[1]. *H.M. Khodr, J. Molea, I. Garcia, C. Hidalgo, P.C. Paiva, J.M. Yusta, A.J. Urdaneta.,* "Standard Levels of Energy Losses in Primary Distribution Circuits for SCADA Applications", in IEEE Trans. on Power Systems, **vol. 17**, no. 3, 2002, pp. 615 – 620.

[2]. *Gh. Cartina, Y.-H. Song, Gh. Grigoras*, Optimal Operation and Planning of Power Systems, VENUS Publishing House, Iasi, 2003.

[3]. *V. Alexandrescu, Gh. Cartina, and Gh. Grigoras,* "Using Fuzzy Load Models in Distribution Network Monitoring and Control", in Proceedings of the Modeling and Optimization in the Machines Building Field, Bacau, **vol. 1**, 2001, pp. 236 – 241.

[4]. *Gh. Grigoras, Gh. Cartina,* "Load Analysis in Distribution Systems using Power Fuzzy Correlation Models", Proceedings of the 26th International Conference on Fundamentals of Electrotechnics and Circuit Theory, Gliwice-Ustron, Poland, **vol. 2**, 2003, pp. 323 – 326.

[5]. *Gh. Cartina Gh. Grigoras, and E.C. Bobric,* Tehnici de clustering in modelarea fuzzy. Aplicatii in electroeneregetica (Clustering Techiques in Fuzzy Modeling. Power Systems Applications), VENUS Publishing House, Iasi, 2005.