15. Symposium Energieinnovation, 14. bis 16. Februar 2018, Technische Universität Graz, www.EnInnov.TUGraz.at
ISBN 978-3-85125-585-0 DOI 10.3217/978-3-85125-584-3

ALTERNATIVE SOLUTIONS IN DISTRIBUTION NETWORK DUE TO INCREASING CONSUMPTION AND PEAK GENERATION

Matej PINTARIČ[1], Miran ROŠER[2], Gorazd ŠTUMBERGER[1]

Abstract

In this paper alternative solutions, that deal with increasing consumption in distribution network that already operates near limit load, are presented. Distribution network is powered by a single 31,5 MVA, 110/20 kV transformer with On Load Tape Changer. Two bigger industrial consumers are connected directly to 20 kV network whilst over 2500 consumers are connected at 53 20/0,4 kV transformers. Figure 1 shows the simplified one-line diagram of the distribution network, substations with switching capabilities and two bigger industrial consumers connected at substations Žerjav and Topla.

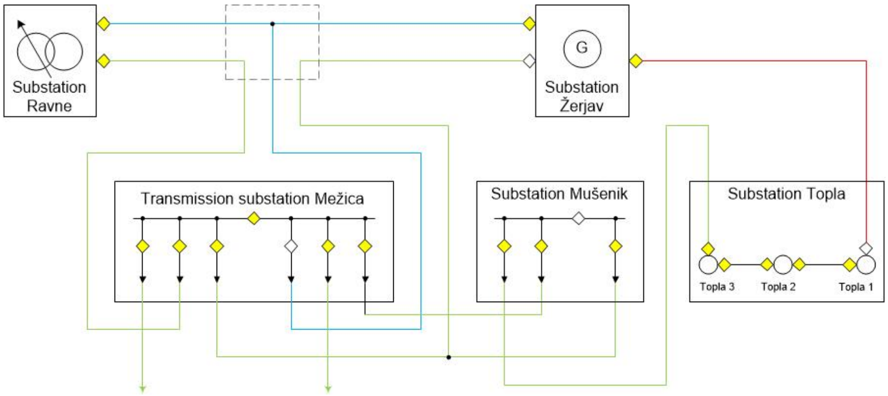

Figure 1: Simplified one-line diagram of discussed 20 kV distribution network

The two industrial consumers intend to extend their activities. Therefore, they requested the increase of installed power at Žerjav from 6,5 MW to 9 MW and at Topla from 6 MW to 6,5 MW. Since the network already operates near the maximal allowed voltage drop limit, the proposed increase in installed power cannot be granted. A proper solution to this problem is to build a new 110 kV line directly to Žerjav. However, it could take years before the problems related to the right of way are solved and the project is approved. The aim of this work is to check if an alternative solution can temporary enable the requested increase of installed power of industrial consumers. The analysis is performed under assumption that 20 kV network is symmetrical. Therefore, the single-phase network model presented in [1] is used in all load flow calculations. For the analysis of radial network Backward Forward Sweep (BFS) [2] load flow method is applied. In order to extend the analysis toward weakly meshed networks, Modified Backward Forward Sweep method [3] is introduced.

Applying optimization algorithm called Differential Evolution [4], with incorporated load flow method, the maximal installed powers of the two industrial loads were determined. The optimization bounds were maximal line currents and voltage limits in the range of ±3 %, ±5 %, ± 8% of nominal voltage. During the optimization procedure, the maximal powers of all other loads in the network were considered whilst the contribution of distributed generation units was neglected. The results of the calculation are the maximal acceptable installed power of the industrial load at locations Žerjav and Topla. They are given for different bus voltages at substation Ravne in Table 1. The maximal acceptable voltage drop considered was 8 %. However, the limiting factor at location Žerjav was not the voltage limit but the current overload of the cable. Additional actions to improve the voltage conditions in the network and to enable higher installed powers at locations Žerjav and Ravne were the inclusion of 0.5 MVA hydropower plant Žerjav with reactive power control, the use of a capacitor bank at substation Mežica and the network reconfiguration, including closed loop operation with the loop Ravne – Mežica – Žerjav – Ravne, where feeders normally operate in radial arrangement.

[1] University of Maribor, Faculty of Electrical Engineering and Computer Science, Smetanova uilca 17, 2000 Maribor, Slovenija, Tel.: +386 2 220-{7085|7075}, {matej.pintaric1|gorazd.stumberger}@um.si
[2] Elektro Celje d.d., Vrunčeva ulica 2a, 3000 Celje, Slovenija

ISBN 978-3-85125-585-0 DOI 10.3217/978-3-85125-584-3

VOLTAGE ZONE	SWING VOLTAGE [KV]	POWER AT ŽERJAV [MVA]	POWER AT TOPLA [MVA]
±3 %	20,6	/	/
±5 %	21	7,46	3,56
±8 %	21,3	10,57*	7,22

Table 1: Maximal power results without distribution generation

An additional problem that had to be solved, beside the problems with too high voltage drops, were too high voltages at night hours at peak generation of hydropower plant Žerjav. These problems were effectively solved by the network reconfiguration and controlled reactive power generation at Žerjav. Figure 2a shows an example of too high voltage profile at peak generation of hydropower plant Žerjav, which is effectively solved by one of possible network reconfiguration and reactive power generation, as shown in Figure 2b.

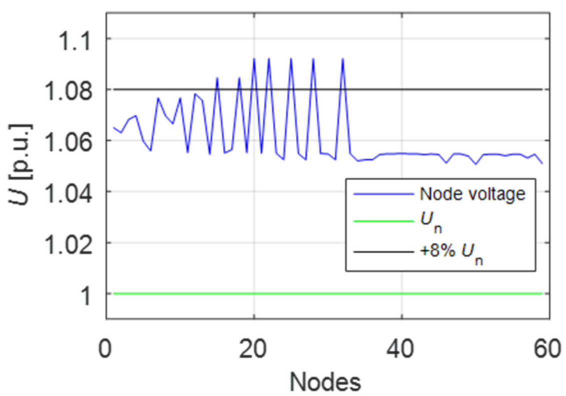

Figure 2a: Voltage profile at peak generation

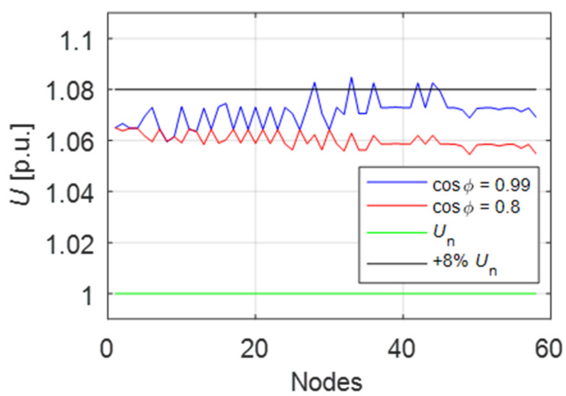

Figure 2b: Voltage profile at changed configuration and reactive power generation

The applied approach was sufficient to temporarily enable the requested increased installed power of industrial loads. However, such operation is not standard and requires permanent monitoring and operator actions, if required.

References

[1] M. Pintarič, "Optimizacija obratovanja razdeljevalnega omrežja s spreminjanjem konfiguracije in generiranjem jalove moči," Master's Thesis, University of Maribor, 2016.

[2] G. W. Chang, s. Y. Chu and H. L. Wang, "An Improved Backward/Forward Sweep Load Flow Algorithm for Radial Distribution Systems," IEEE Transactions on Power Systems, vol. 22, no. 2, pp. 882 - 884, 2007.

[3] G. X. Luo and A. Semlyen, "Efficient load flow for large meshed networks," IEEE Transactions on Power Systems, vol. 5, no. 4, pp. 1309 - 1316, 1990.

[4] P. Rocca, G. Oliveri and A. Massa, "Differential Evolution as Applied to Electromagnetics," IEEE Antennas and Propagation Magazine, vol. 53, no. 1, pp. 38 - 49, 2011.