IMPACT OF SAVICA HYDRO POWER PLANT OPERATION ON VOLTAGE QUALITY AND PRACTICAL EXPERIENCE IN IMPLEMENTING NEW VOLT/VAR CONTROL SYSTEM ARCHITECTURE

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ABSTRACT

Distributed generation (DG) in distribution networks has potentially a strong influence on quality of operation especially in combination of low load consumption and high production. High voltage levels usually go hand in hand with reverse power flow, as energy from DG is pushed further up even into transmission network. Since the distribution networks are primarily designed to accept power from transmission network, that kind of operation is therefore rarely foreseen.

Article deals with practical experience on active network voltage management due to impact of the Savica hydro power plant (HPP) in Bohinj region during stand-by supply.

INTRODUCTION

Distributed generation (DG) in distribution networks has potentially a strong influence on quality of operation especially in combination of low load consumption and high DG production. High voltage profiles usually go hand in hand with reverse power flow, as energy from DG is pushed back into HV transmission network. Since the distribution networks are primarily designed to accept power from transmission network, that kind of operation is therefore rarely foreseen.

The paper describes practical approach and experience on active network voltage management due to impact of the Savica hydro power plant (HPP) in Bohinj region during stand-by supply. After the high voltage levels were discovered, detailed network operation analysis based mostly on different monitoring systems readings was performed. After the correlation between low regional load consumption and high power plant production was confirmed, field measurement of voltage levels were performed. Taking into account different network configurations combined with active and reactive power plant control, the effects of HPP VAR control on voltage levels were established. Network model analyses and on site tests confirmed analytical results.
Taking into account future distribution automation, the implementation of Volt/Var control (VVC) as standard distribution management function (DMS) in distribution control center (DCC) is foreseen. Efficient and reliable real time voltage levels reading within the distribution network and high quality distribution network model will become of the outmost importance.

Recognizing those challenges Elektro Gorenjska has joined the "Intelligent power system platform for supervision and control of distributed generation and customer demands" project, where first intelligent electronic devices named Point of Common Cuppling Interface (PCCI) have already been installed and tested. PCCI will enable real time measurement data and so far different voltage quality data has been integrated within the SCADA in DCC.

BOHINJ NETWORK VOLTAGE ANALYSIS

Bohinj territory is situated at the NW part of Elektro Gorenjska distribution network and in normaly supplied with 35 kV line from distribution transformer station (DTS) Moste, 25 km away (Figure 1.) . The 20 MVA, 35/20 kV, transformation in DTS Bohinj supplies local middle voltage (MV) network. Several hydro power plants (HPP), connected either to low (LV) or directly on MV network have significant impact on voltage quality due to unpredictable local hydro potential. As the production is often much higher than demand, local overvoltages were registered.

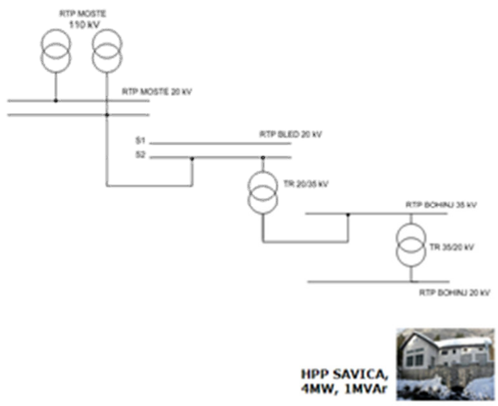


Figure 1: Bohinj single line network diagram, normal operation - 35 kV supply.

Voltage quality is further reduced in the case of 35 kV line failure, when Bohinj is supplied by 20 kV line directly (Figure 2.)

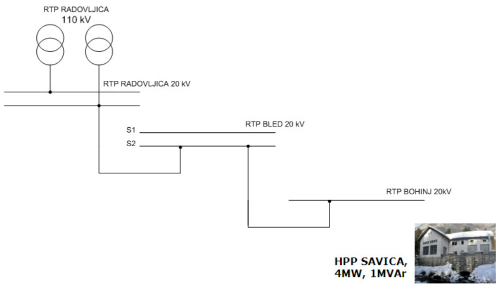


Figure 2: Bohinj single line network diagram, stand-by operation - 20 kV supply

After the local high voltage levels were registered, detailed network operation analysis based mostly on different monitoring systems readings were performed. Different network locations (Figure 3.) were analysed, trying to obtain voltage profile along MV line supplying HPP Savica at the far end of the MV feeder.

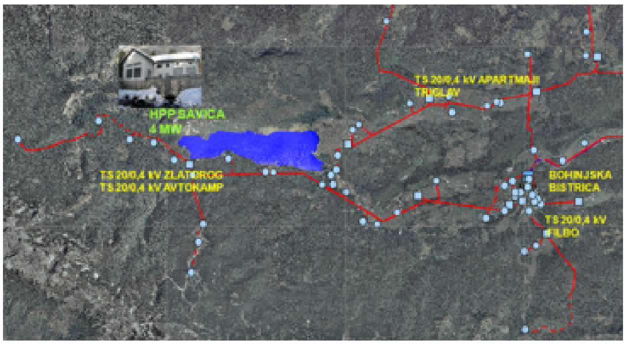
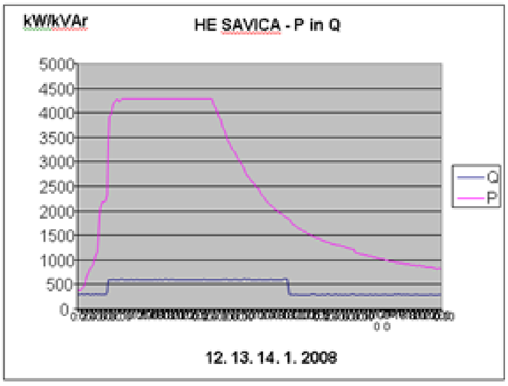
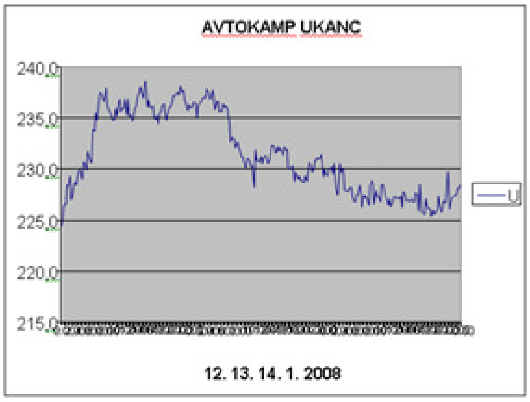
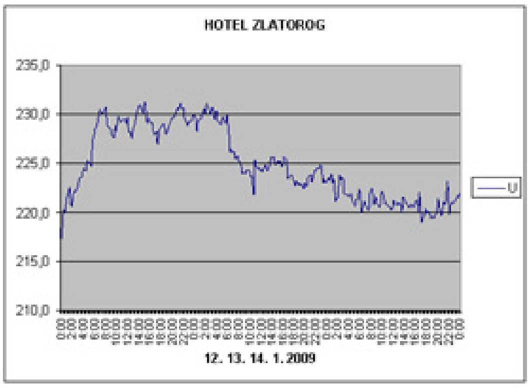


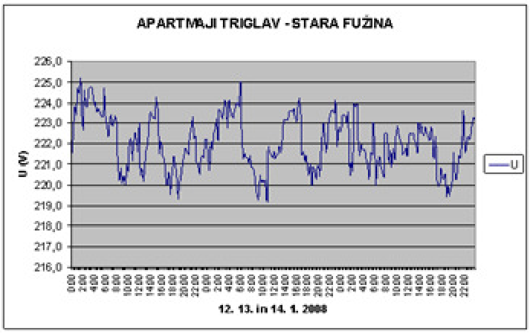
Figure 3: Bohinj topology, HPP Savica location, MV lines and measuring points.

Analyses were performed for normal and stand-by supply and with Savica HPP on minimum and maximum generator power.



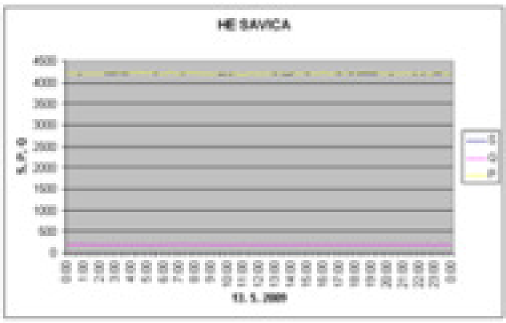


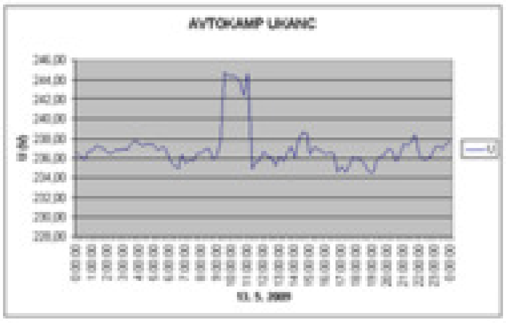


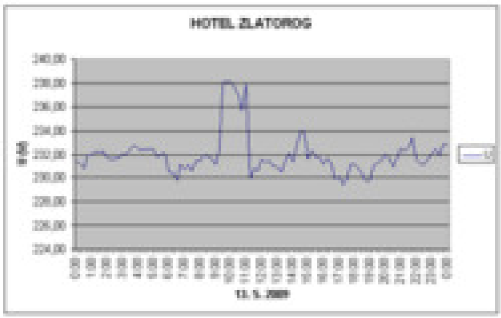


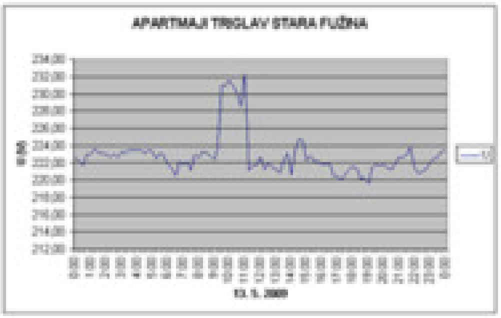
Figures 4. to 7: Voltage profiles, normal 35 kV supply, HPP Savica at minimal and maximal generator power.

At normal 35 kV (Figures 4 to 7.) supply, analysis revealed local voltage rise for around 5 % (average values up to 240 V in LV network) in case of maximal active and reactive Savica HPP generation, while in the case of 20 kV backup supply (Figures 8 to 11.), voltage in the vicinity of HPP was approximately 10 % higher (average values up to almost 250 V on LV network). Maximum HPP generator power in both cases was 4.2 MW (active) and approximately 600 kVAr (reactive capacitive character).









Figures 8. to 11: Voltage profiles in case of 20 kV stand-by supply, HPP Savica at maximum generator power.

FIELD MEASUREMENTS OF SAVICA HPP INFLUENCE ON VOLTAGE QUALITY

Analyses verified the substantial HPP impact on the local voltage network levels. In order to obtain accurate and detailed voltage diagrams related to different HPP operational parameters, on field voltage quality measurement were performed. Different measuring points starting from the 110 kV injection point (DTS Radovljica) to the far end of HPP Savica MV network were carefully chosen in order to obtain accurate voltage profile of the complete region.

HPP Savica parameters and load flow directions

During the test, the operational parameters of HPP Savica were controlled as follows:

- active power control from 0 to maximum generator power in steps (0, 1, 2, 3, 4 MW)
- reactive power control from ± 1000 kVAr (capacitive to inductive)

Since the energy produced in Bohinj region is regularly pushed further up into transmission 110 kV network, test scenarios were as follows:

DTS Bohinj – minimal demand, energy direction towards 110 kV injection point (sundays and nights from 4.00 do 6.00 h)
DTS Bohinj – maximal demand, energy direction towards Bohinj (working day from 6.00 do 8.00 h)

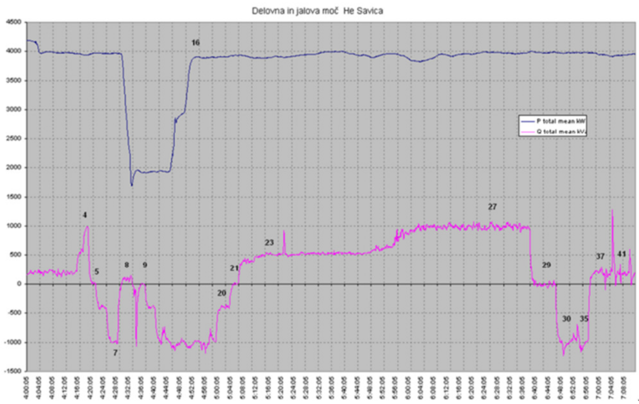


Figure 12: HPP Savica active and reactive power diagram.

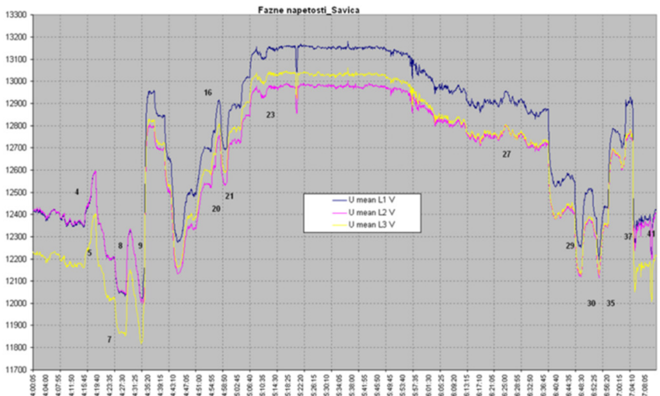


Figure 13: HPP Savica phase voltages diagram.

Measurements shown in Figures 12. and 13. reveal strong correlation of Bohinj region local voltage levels with operation parameters of HPP Savica. HPP Savica operation at maximum active (4MW) and reactive (1MVAr) power lead to high local overvoltages, which can not be acceptable as normal operating conditions.

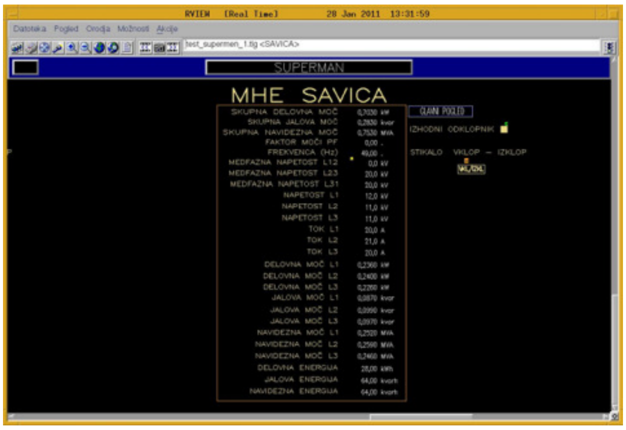
Bohinj voltage levels can be improved with applying HPP Savica reactive power control by the means of controlling generator excitation voltage.

Reactive power control represents the first and effective measure to assure voltage reduction in Bohinj region, particularly in case of 20 kV backup supply .

THE IMPLEMENTATION OF VOLT/VAR CONTROL (VVC)

In 2011 Elektro Gorenjska joined the "Intelligent power system platform for supervision and control of distributed generation and customer demands project, where first intelligent electronic devices named Point of Common Cuppling Interface (PCCI) have been developed and tested.

PCCI enables real time data measurements including remote control and during the project one was installed in Savica HPP. All acquired data has been integrated within the SCADA in the distribution control centre. Besides monitoring all major HPP parameters, some remote switching functions have been activated, as can be seen in Figure 14.



Figures 14: HPP Savica SCADA mask.

Taking the HPP Savica influence on voltage quality into account and the possibilities to control HPP parameters (reactive and active energy) the idea of implementing Volt/Var control function in SCADA distribution management functions had arised.

Based on quality SCADA/DMS network model, reliable real time network parameters and Volt/Var control function, different control strategies are foreseen.

Proposed control system architecture is shown in Figure 15. PCCI devices should be installed in HPP and around Bohinj territory in all transformer stations, enabling real time measurement to SCADA. The implementation of VVC application function should assure proper voltage profiles along the supply line, defining set points for HPP Savica active and reactive power production and the position of on load tap changer on supplying 35/20 kV transformer in distribution transformer station.

With the installation of modern on load tap changer 20/0,4 kV transformers, it is expected to bring VVC control even on this voltage level.

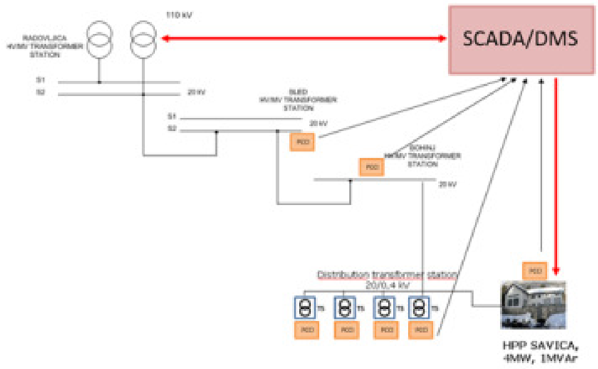


Figure 15: Proposed VOLT/VAR control system architecture.

CONCLUSIONS

Most modern SCADA/DMS systems support Volt/Var control functionality. Proper DMS model design and real time data system acquisition and control system will enable VVC implementation to assure acceptable voltage quality along local network.

With the implementation of proposed system, Elektro Gorenjska should definitely postpone the need for network reinforcement, which is to be expected in case VVC should not be implemented.