VOLTAGE CONTROL IN A TRANSMISSION SYSTEM AREA WITH HIGH RENEWABLE ENERGY PENETRATION

CASE STUDY: CHUNNAKAM GRID SUBSTATION

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Degree of Master of Science

Department of Electrical Engineering

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DECLARATION PAGE OF THE CANDIDATE & SUPERVISOR

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ABSTRACT

The northern part of Sri Lanka has higher wind and solar penetration. Chunnakam and Kilinochchi grid substations are operating in that area, and they are connected to the national grid via a 132 kV double-circuit transmission line from New Anuradhapura to Chunnakam. The Ceylon Electricity Board (CEB) owned thermal power plant (Chunnakam thermal power plant – 8 MW×3) and several private wind plants are operating in the northern area, and those generation plants are connected to 33 kV distribution feeders of either Chunnakam or Kilinochchi grid substation.

Synchronous generators have been the main source of dynamic reactive power control in conventional power systems. However, the replacement of conventional power plants by inverter-based generation resources, such as wind power plants, has resulted in diminished dynamic reactive power reserve at the system level.

According to the CEB standards, acceptable high voltage variation under normal operating condition is, 5% from the rated voltage. During the peak period high voltage levels of the Chunnakam grid substation go below the acceptable limits due to the high demand and low wind power generation. To supply power at the required voltage, thermal power plants connected to the Chunnakam grid substation are operated during peak time. However, when demand increases, these thermal power plants are not sufficient to control the voltage levels.

On the other hand, during off-peak times, high voltage levels of the Chunnakam and Kilinochchi grid substations go over the acceptable limits due to the Ferranti effect. The current solution being practiced by the utility is to isolate one of the double-circuit transmission lines from New Anuradhapura to Chunnakam, and control the voltage levels by increasing transmission line losses. This is an inefficient voltage control mechanism.

In this research, a case study is carried out to develop a voltage control method for Chunnakam, Kilinochchi, and Vavuniya grid substations, and a voltage control scenario is developed based on the ten years forecasted demand and renewable distributed generation in those areas. Reactive power compensation by shunt capacitor and battery energy storage systems were the two main voltage control techniques that

are considered for the study and the best solution for selected area transmission network was selected through a tech-economic evaluation

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ABBRIVIATIONS

CEB	-	Ceylon Electricity Board
BESS	-	Battery Energy Storage System
DG	-	Distributed Generation
MV	-	Medium Voltage
HV	-	High Voltage
LTGP	-	Long Term Generation Plan
SC	-	Synchronous Condenser
SVC	-	Static VAR Compensator