



IMPACT ANALYSIS OF 220 KV AND 400 KV TRANSMISSION LINES ON THE INTEGRATED NEPAL POWER SYSTEM

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Abstract

Power is an essential requirement for the economic development of any country. To maintain the generation of electric power at an adequate level the power has to be transmitted in a proper form to the consumer. For determination of line losses, voltage profiles and expansion of system, load flow analysis is most essential tools. This paper deals with the impact analysis of new 220 kV and 400 kV lines on Interconnected Nepal Power System (132 kV grid) in Electrical Transient Analyzer Program (ETAP). It represents the present scenario of the power system of Nepal and their impact analysis. Load flow result of existing 132 kV line shows that there is about 44.56 MW active power losses in the transmission line before any compensation techniques. After the Optimal Capacitor Placement, in the existing transmission line the active power loss decreases to about 34.224 MW as well as the voltage profile at each bus improves. The load flow result of the under construction 220 kV and 400 kV lines on the existing line shows that the total system loss would decrease to about 27.445 MW with the voltage profile improvement. The simulated model, result and analysis are presented in this paper.

Keywords

ETAP, Grid, INPS, Load Flow, Optimal Capacitor Placement, Power loss

1 Introduction

It is necessary to provide an uninterrupted power supply. An interconnection of power system increases the reliability of supply, reduces the reserved capacity, improves the load factor, diversity factor and efficiency. The interconnection makes use of more efficient plant as base load plant and less efficiency plant as peak load plant possible and reduce the capital cost per kW and overall cost per

unit generation.^[2] However, the problems of load and frequency control are more difficult in a large interconnected system with many power stations scattered over a wide range in comparison with a system having one or two generating stations. Nepal is country with a high potential of hydroelectric energy, which has been estimated to 83000 MW out of which 43000 MW has been identified as economically viable.^[1] Electrical energy is generated at the

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power stations which are situated far away from load centers. Hence an extensive network of conductors between power stations and consumer is required. In present situation, the national grid of Nepal comprises 132 kV transmission line. There are many under construction 220 kV and 400 kV transmission lines which are soon to be charged.^{[4][5]} In the present situation, transmission line losses of Nepal is around 5%.^[5] Charging of high voltage line can greatly reduce the line losses. Similarly, capacitor placement at optimal position can help to provide the reactive power and improves the voltage profile. Thus, the expansion of the system and upgrading of system voltage is essential to provide the quality of electrical energy to the consumer level. For this, load flow analysis of the existing system is to be carried out. It is also equally important to analyse the impact of new high voltage lines on the existing system.

Several research works related to impact analysis of new lines on existing system have been reported.^{[1][4]} Impact study of the Khimti-Dhalkebar 220 kV line shows a reduction of losses in the system by 15.639 MW and a significant improvement in the voltage profile after commissioning of this line^[4] Impact study of 220kV Hetauda-Bhardaghat line also shows the significant reduction of losses in the system^[1]. The first model developed in this research is of existing 132kV lines with 115 buses. Here hydropower with installed capacity more than 5MW has been considered to make the total system capacity of 834MW. After that, using the ETAP tools OCP, the rating of capacitor has been determined and placed in respective substations which reduces the losses and improve the voltage profile.

Interconnection and charging of five 220kV and two 400kV under construction lines, a new model with 146 buses has been developed and simulated in ETAP to understand the load flow and impact on the existing system.

2 Methodology

To analyze the impact of 220 kV and 400 kV transmission lines on the Integrated Nepal Power System, following procedures were followed.

2.1 Data Collection

The necessary data were collected from NEA annual reports, and papers related to load flow analysis of INPS. In addition, some data were collected through site visits of hydropower and substations.

2.2 Modelling

An appropriate model of the system was built in ETAP. The first model developed in this research was existing 132 kV lines with 115 buses. After that, using the ETAP tools OCP, the rating of capacitor has been determined and placed in respective substations. Next model was developed by connecting five 220 kV and two 400 kV under construction lines with 146 bus.

2.3 Load Flow

After the development of two different models, they were simulated on ETAP. Load flow analysis was conducted to determine the power flow through different lines, line losses and voltage at different buses.

2.4 ETAP

ETAP stands for Electrical Transient Analyzer Program. ETAP is the most comprehensive analysis tool for the design and testing of power systems available. Using its standard

offline simulation modules, ETAP can utilize real-time operating data for advanced monitoring, real-time simulation, optimization, energy management systems, and high-speed intelligent load shedding. The model was built in ETAP and load flow and Optimal Capacitor Placement (OCP) was performed. The result so obtained is used in the analysis of the system.

3 Load Flow Result And Analysis

3.1 Load Flow result of existing 132kV line

The sectionalized view of simulation model of the existing 132 kV line of INPS without OCP is as shown in Figure 1. The system consists of 115 buses.

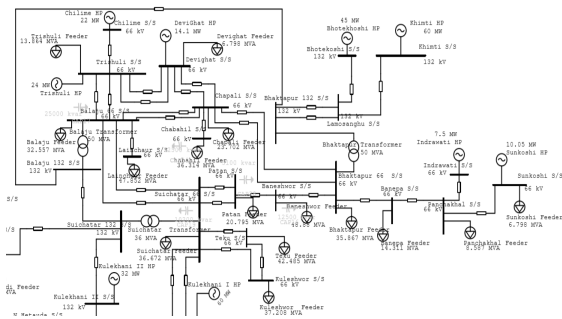


Figure 1: Sectionalized view of 132 kV Existing INPS

Loading of Transformer. The percentage loading of major critical transformer are listed in Table 1.

Table 1. Loading of critical Transformer before OCP

| Transformer | Loading (input) MVA | % Loading (input) | Loading (output) MVA | % Loading (output) |
|-----------------------------|---------------------|-------------------|----------------------|--------------------|
| Balaju Transformer 50MVA | 58 | 116 | 53.66 | 107.3 |
| Bhaktapur Transformer 50MVA | 60.033 | 120.1 | 55.72 | 114.4 |

| Suichatar Transformer 36MVA | 48.149 | 133.7 | 43.72 | 121.4 |
|-----------------------------|--------|-------|-------|-------|
|-----------------------------|--------|-------|-------|-------|

OCP simulation. The sectionalized view of simulation model of the existing 132 kV line of INPS with OCP is as shown in Figure 2. The capacitor banks were placed at 15 different substations like Butwal, Bharatpur, Balaju, Lahan, Simara, Hetauda, Dhalkebar, Parwanipur, etc. with about total capacity of about 223.8 MVAR.

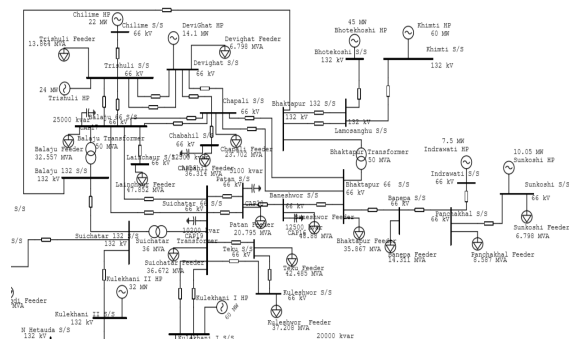


Figure 2: Sectionalized view of existing 132 KV INPS with OCP

Loading of Critical Transformer after OCP. The percentage loading of same critical transformers after capacitor placement is shown in Table 2.

Table 2. Loading of critical Transformer after OCP

| Transformer | Loading (input) MVA | % Loading (input) | Loading (output) MVA | % Loading (output) |
|-----------------------------|---------------------|-------------------|----------------------|--------------------|
| Balaju Transformer 50MVA | 48.487 | 97 | 47.406 | 94.8 |
| Bhaktapur Transformer 50MVA | 52.419 | 104.8 | 50.857 | 101.7 |
| Suichatar Transformer 36MVA | 38.622 | 107.3 | 37.354 | 103.8 |

From the above comparison, after OCP

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overloaded transformer of Balaju operates under normal loading. Similarly, the overloading percentage of Bhaktapur and Suichatar transformer reduces.

Line Losses. Total system active loss before OCP was 44.56 MW which reduces to 34.224MW after OCP. This shows the significant reduction in active power losses after the installment of a capacitor bank. The bar diagram shows some of the lines which had loss more than 1MW and their reduction in loss after capacitor placement.

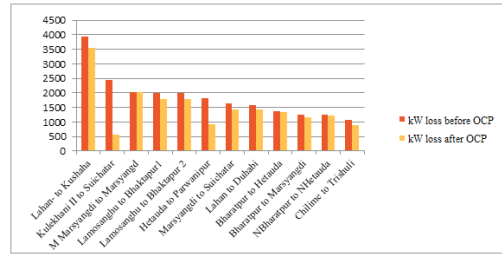


Figure 3: Active Power Loss before and after OCP

Bus Voltage Profile. Voltage profile of bus improves with the installation of OCP. The following Table 3 shows the bus voltage of some critical bus before and after OCP. The comparison shows that voltage profile improves in significant manner.

Table 3. Bus Voltage profile before and after OCP

| Device ID | Type | Rating (kV) | Operating Before OCP (kV) | % Operating | Operating After OCP (kV) | % Operating |
|----------------------|------|-------------|---------------------------|-------------|--------------------------|-------------|
| Chandranigahapur S/S | BUS | 132 | 121.625 | 92.3 | 127.275 | 96.4 |
| Devighat S/S | BUS | 66 | 57.339 | 86.9 | 63.702 | 96.5 |
| Dhalkebar S/S | BUS | 132 | 119.726 | 90.7 | 127.221 | 96.4 |
| Hetauda S/S | BUS | 66 | 57.413 | 87 | 62.896 | 95.2 |
| Kulekhani I S/S | BUS | 66 | 58.369 | 88.4 | 63.980 | 96.9 |
| Lahan S/S | BUS | 132 | 121.757 | 92.2 | 128.957 | 97.7 |
| Suichatar S/S | BUS | 132 | 122.721 | 93 | 128.083 | 97 |

3.2 Load flow result of existing INPS after 220 kV and 400 kV line energized

The sectionalized view of simulation model of the existing 132 kV line of INPS after the interconnection of under construction 220 kV and 400 kV is as shown in Figure 3. Under construction 220 kV lines Khimti - Dhalkebar, Heutada - Bharatpur, Bharatpur - Bardaghat, Marsyangdi -Kathmandu, Lekhnath - Damauli and 400 kV lines Hetauda - Dhalkebar - Duhabi,

Dhalkebar - Muzzaffarpur were interconnected in the existing 132 kV system. There were 146 buses in the new system.

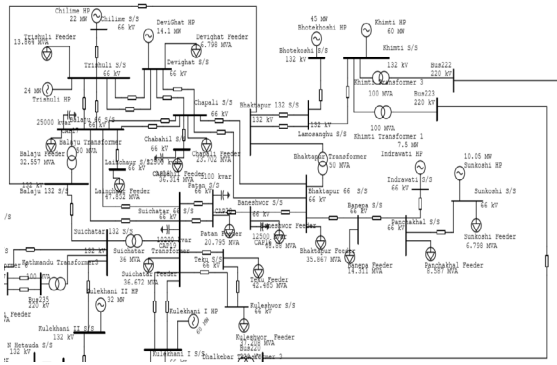


Figure 4. Sectionalized view of 132 kV Existing INPS with 220kV and 400kV Line Charged
Line Losses. After the charging of high voltage transmission lines of 220 kV and 400 kV, active power losses will decrease which improves the efficiency of lines. Before charging of 220 kV and 400kV lines, the total system loss is 34.224MW which can reduce to 27.445MW after charging the line. The bar diagram shows the comparison of line losses of some lines before

and after charging of high voltage lines. The result shows a significant reduction of line losses.

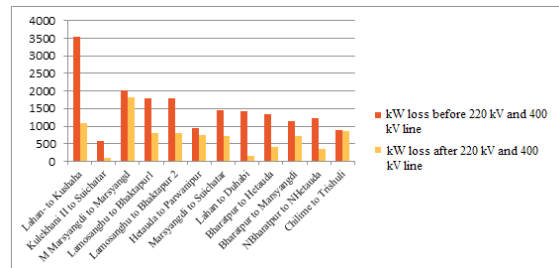


Figure 5. Active Power losses before and after Charging of 220kV and 400kV Lines

Bus Voltage profile. Voltage drop at different bus decreases after the charging of 220 kV and 400kV line which results into improved voltage profile. The table below shows the voltage at different critical bus before the charging of high voltage lines. The comparison shows the improvement of voltages to near 1 per unit after charging of new lines.

Table 4. Bus Voltage profile before and after charging of 220 kV and 400 kV line

| Device ID | Type | Rating (kV) | Operating Before 220 and 400kv line (kV) | % Operating voltage | Operating After 220 and 400kv line (kV) | % Operating Voltage |
|-----------------|------|-------------|--|---------------------|---|---------------------|
| Balaju 66 S/S | BUS | 66 | 62.283 | 94.4 | 64.435 | 97.6 |
| Chabahil S/S | BUS | 66 | 61.400 | 93.0 | 63.573 | 96.3 |
| Kuleshwar S/S | BUS | 66 | 61.607 | 93.3 | 63.739 | 96.6 |
| Suichatar66 S/S | BUS | 66 | 61.939 | 93.8 | 64.060 | 97.1 |

4 Conclusion

The impact analysis and comparison carried out in this project has led to the Conclusion that, the charging of under construction 220kV and 400kV lines will increase the power handling capacity of the system with a significant reduction in the transmission loss. The existing system loss is about 5% which can be reduced to 4.1% with optimal capacitor placement.

Again, after the charging of 220kV and 400kV line over all transmission loss will be reduced to 3.29% if the required compensating devices are installed at different buses. Reduction in overall transmission loss improves system efficiency. This will also increase the power transfer capability of line since there will be no overloading of line in case of the addition of

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major under construction hydropower project. This will also improve the voltage profile of bus.

This indicates requirement of implementation of other new high voltage transmission lines in INPS network for connecting the major under construction hydropower project without overloading of line and increase the power transfer capability of overall system. This also shows the requirement of reactive power compensation with installation of optimal capacitor banks and different FACTS devices at different substation.

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