Impact study of Khimti-Dhalkebar 220 kV Transmission Line on the Operation of Integrated Nepal Power System

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Abstract: At present Nepal faces power deficit, due to severe imbalance in demand and supply of electricity in the country. In absence of high voltage transmission lines, the system operator has faced difficulty in evacuating power generated at few plants causing loss to the utility as well as increase in power cut hours. Projects like Khimti-Dhalkebar 220kV Transmission Line are facing prolonged delays because of several issues including unwillingness of project affected people to cede their land to the project. As Integrated Nepal Power System (INPS) has most of its generation concentrated in the central mid hills of the country ranging from Dolakha- Ramechhap in the eastern part to Syangja-Baglung in the western part. The high power demand in eastern industrial area like Duhabi-Biratnagar industrial corridor needs to be supplied from Hetauda via Dhalkebar substation. The construction of Khimti-Dhalkebar Transmission Line (KDTL) is intended to route power generated in Tamakoshi-Bhotekoshi basin to the eastern part of Nepal. This research work aims to compute the amount of power and energy loss reduction in INPS as a result of commissioning of KDTL and also intends to estimate the benefit in terms of monetary value. After data collection of INPS, a test model of INPS was made and power flow was done using software. The result shows that about 15.639MW Power loss can be saved by commissioning of KDTL. Analysis also shows that there is increase in loadability margin by about 0.8174 p.u. in INPS as a result of commissioning of KDTL so voltage stability of the system is significantly improved. The developed model test results and analysis are presented in this paper.

Keywords: Transmission line, load flow, power loss

1. Introduction

Nepal has an immense potential of hydropower resources. Theoretically, hydropower potential of Nepal has been estimated at 83,000 Mega Watt (MW) of which 42,000 MW has been estimated to be economically feasible. Pharping, the first hydroelectric power plant of Nepal [1], started generating electricity in 1911 A.D. Despite having a century long history of electricity generation and consumption, half of the population is still deprived from use of electricity and other half is facing long hours of power cut. The current crisis of electricity requires the best planning and its implementation in the power system of Nepal with clear vision and positive attitude.

Transmission system plays very important role in the bulk transfer of electrical energy, from generating power plants to electrical substations located near demand centers. Most transmission lines are high-voltage three-phase alternating current. Electricity is transmitted at high voltages (132 kV or above) to reduce the energy losses in long-distance transmission. Transmitting electricity at high voltage reduces the fraction of energy lost to resistance, which varies depending on the specific conductors, the current flowing, and the length of the transmission line.

Despite having a large hydro potentiality at present Nepal faces power deficit, due to severe imbalance in demand and supply of electricity in the country. The annual peak electricity demand is increasing with an average of 9% annually [2]. It has led to unprecedented load shedding since the last 6-7 years, and this situation is expected to continue in the coming 4-5 years. It has resulted negative impact on overall development of the nation and inconveniences to the consumers.

Currently, many independent power producers (IPP) are also putting their efforts on developing hydroelectric projects to address power demand of Nepal as well as export excess power to India. However in absence of high voltage transmission lines generated power is also not transmitted to other parts as well as import power from India to address the present power crisis of Nepal. The only existing 132 kV transmission line capacity is not sufficient for transmitting generated power in the country. Further, in absence of high voltage transmission lines the loss of power is also high that could be saved by construction of new high voltage transmission lines.

National Grid is facing congestion in the following sections [3]:

Hetauda-Bharatpur-Bardghat 132 kV, Marsyangdi-Kathmandu 132 kV, Pokhara-Bharatpur 132 kV, Sunkosi-Bhaktapur 66 kV and Trisuli-Kathmandu 66 kV. System collapse takes place under any one of the contingency conditions [3]:

- Kaligandaki-Pokhara 132 kV link disrupted
- Tripping of Bardaghat-Bharatpur and/or Bharatpur- Hetauda 132 kV lines
- Tripping of Marsyangdi-Siuchatar 132 kV line
- Tripping of Khimti-Bhaktapur 132 kV line

So, new transmission line is needed to protect the grid from above problems. To meet present increasing demand of power generation, the existing capacity of the transmission needs to be upgraded or new transmission line should be constructed. So Transmission Line Expansion is necessary:

- To alleviate congestion and improve system reliability
- To increase the ability to distribute available power to meet existing and future demands.
- To meet NEA's contractual obligation for transmission with various power producers
- To increase NEA's ability to import/export power
- To replace older transmission lines that are in poor condition and no longer reliable.
- To prevent equipment overloads and low voltages.

The KDTL project was started in 2059/60 with the objective of enhancing transmission capacity, improving supply reliability, reducing losses and voltage drops through construction of 220 KV double circuit line and was scheduled to be completed in 2067/68(2010/11)[4].The KDTL starts from Kirnetar settlement of Dolakha district and terminates at Dhalkebar substation of Dhanusha district. The total length of the alignment is approximately 75 kilometers. The KDTL is the first 220 kV transmission line project in Nepal. The main objective of the construction of Khimti - Dhalkebar 220 kV Transmission line is to evacuate the power generated from proposed Upper Tamakoshi Hydroelectric Project including other hydro power project in the regions. The transmission line will also be connected with two existing plants, namely; Khimti Hydropower Plant (60 MW) and Bhotekoshi Hydropower Plant (36 MW). This transmission line project also plans to export power to India as well as to supply power to the population of Eastern Region of the country.

2. Methodology

To determine the the impact of Khimti-Dhalkebar 220 kV Transmission line on the operation of INPS following steps were followed during the paper works:

A. Data collection

Datas related to INPS and of Khimti-Dhalkebar 220 kV Transmission line were collected and necessary calculation were done.

B. Modeling

The appropriate models were developed for representing INPS. Then these models were used for having the detailed analysis so as to meet with the aims of the research work.

C. Load Flow Solution

In a three phase power system active and reactive power flows from the generating station to the load through different networks bushes and branches. The flow of active and reactive power is called power flow or load flow. Power flow studies provide a systematic mathematical approach for determination of various bus voltages, phase angles, active and reactive power flows through different branches, generators and loads under steady state condition.

Once the load flow is solved, further analysis such as contingency analysis can be easily performed. In this study power flow analysis is used to determine the power loss on each branches using Power System Analysis Toolbox (PSAT) incorporated in MATLAB.

In load flow analysis, first voltage at each bus is determined after that line flow from one bus to other is determined.

The complex powers S_{ij} from bus i to j and S_{ji} from j to i are:

$$S_{ij} = V_i \, I_{ij}^*$$

$$S_{ji} = V_j \, I_{ji}^*$$

The power loss in the line i-j is the algebraic sum of the line power flows:

$$S_{Loss} = S_{ij} + S_{ji}$$

D. Use of MATLAB & PSAT

MATLAB("MATrix LABoratory") is a programming environment for algorithm development, data analysis, visualization, and numerical computation. Using MATLAB, we can solve technical computing problems faster than with traditional programming languages, such as C, C+ and FORTRAN.

The PSAT is a Matlab toolbox for electric power system analysis and simulation. PSAT is very helpful for solving Power Flow, Continuation Power Flow, and Optimal Power Flow etc. In this work PSAT 2.1.8 version is used in MATLAB R2012a.

3. Case Studies

A. Study Case I: INPS without KDTL

Study case first is applied for INPS without KDTL as depicted in Figure 1 which consists of 9 generators, 14 load buses, 4 transformers and 32 lines (branches).The power demand and generation scenario of B.S. 2070/071 has been considered. Power loss is obtained by load flow solution.

B. Study Case II: INPS with KDTL

Study case second is applied for INPS with KDTL as depicted in Figure 2 which consists of 9 generators, 14 load buses, 4 transformer and 33 lines (branches). Power loss in different branches is obtained by load flow solution.

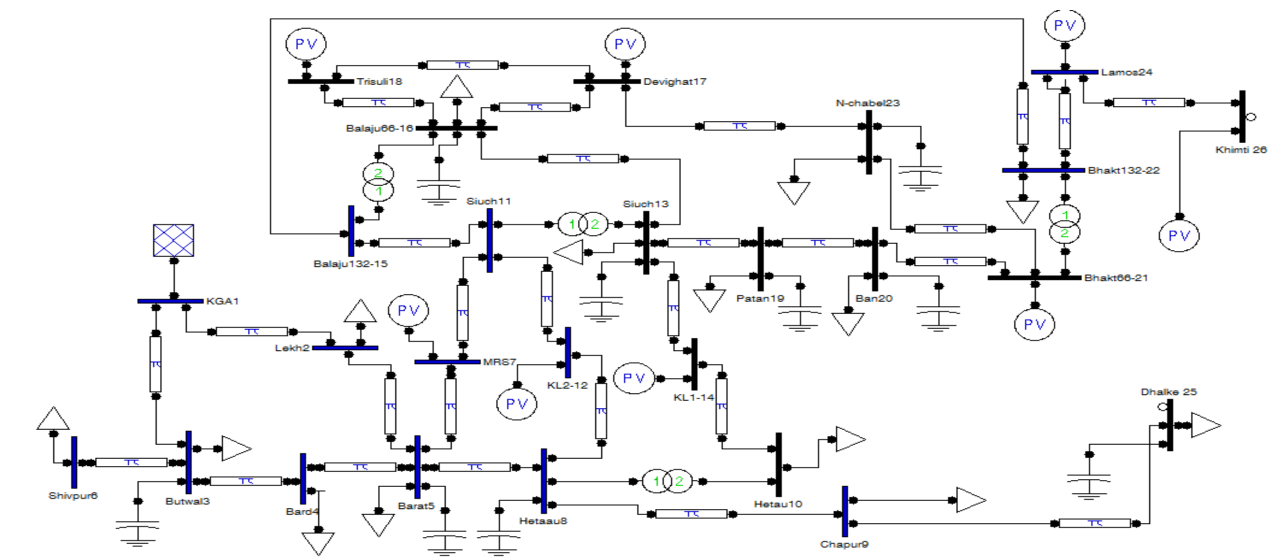

Figure 1: INPS Model without KDTL

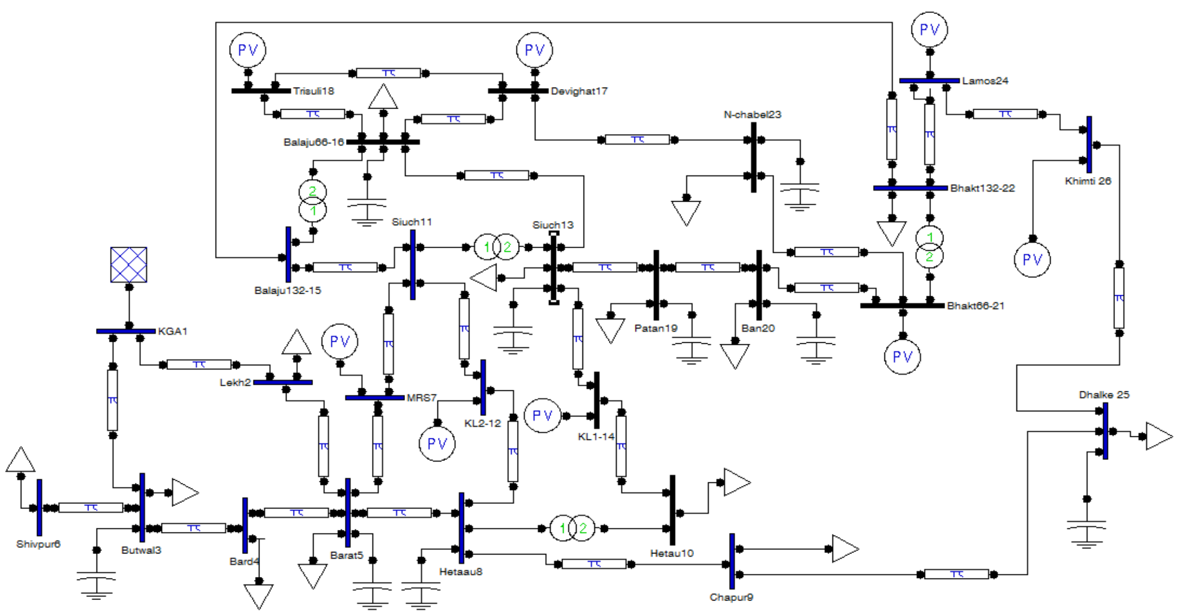

Figure 2: INPS Model with KDTL

4. Results and Discussion

When the collected information of INPS was processed and fed as input data to the developed model, it was successful in searching the optimum solution.

A. Results for INPS without KDTL test system

Table 1: Power Flow Results without KDTL

From Bus	To Bus	Line	P Loss MW
Lekh2	KGA1	1	0.514
KGA1	Butwal3	2	1.376
KL2-12	Siuch11	3	0.78
KL2-12	Hetaau8	4	0.44
Siuch13	KL1-14	5	0.035
KL1-14	Hetau10	6	1.133
Balaju132-1	Siuch11	7	0.16
Balaju66-16	Siuch13	8	0.125
Balaju66-16	Devighat17	9	0.099
Trisuli18	Balaju66-1	10	0.2
Trisuli18	Devighat17	11	0.003
Siuch13	Patan19	12	0.021
Lekh2	Barat5	13	0.598
Patan19	Ban20	14	0.02
Ban20	Bhakt66-21	15	0.147
N-chabel23	Bhakt66-21	16	0.067
Devighat17	N-chabel23	17	0.066
Balju132-1	Bhakt132-2	18	0.415
Lamos24	Bhakt132-2	19	3.919
Chapur9	Dhalke 25	20	3.276
Khimti 26	Lamos24	21	1.095
Butwal3	Bard4	22	0.322
Bard4	Barat5	23	1.739
Shivpur6	Butwal3	24	1.65
Barat5	Hetaau8	25	0.777
MRS7	Barat5	26	2.165
Siuch11	MRS7	27	0.138
Hetaau8	Chapur9	28	9.325
Hetaau8	Hetau10	29	0.142
Siuch11	Siuch13	30	0.023
Balaju132-1	Balaju66-1	31	0.021
Bhakt132-22	Bhakt66-21	32	0.061
Total Loss			30.852

Without using KDTL, load flow has been run using PSAT incorporated in MATLAB. Power loss is obtained from load flow. Total transmission loss of INPS was found 30.852MW on total 463.49 MW generated power. Resuls obtained from power flow is shown in table 1.

Figure 3 shows the Loadability curve without KDTL in which Maximum loading parameter lambda_max in the case of without KDTL is 1.2573. From figure 3 it can be also understood that Dhalkebar bus is the most critical bus.

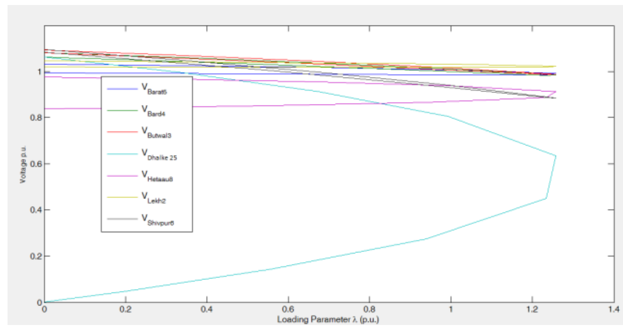

Figure 3: Loadability curve without KDTL

B. Results for INPS with KDTL test system

Using KDTL, load flow has been run using PSAT incorporated in MATLAB. Power loss is obtained from load flow. Total transmission loss of INPS in this case was found 15.213MW on total 462.57 MW generated power.Power loss has been decreased significantly with same load scenario. Resuls obtained from power flow in this case is shown in Table 2.

Table 2: Power Flow Results with KDTL

From Bus	To Bus	Line	P Loss MW
Lekh2	KGA1	1	0.49
KGA1	Butwal3	2	1.341
KL2-12	Siuch11	3	0.43
KL2-12	Hetaau8	4	0.249
Siuch13	KL1-14	5	0.599
KL1-14	Hetau10	6	0.383
Balaju132-1	Siuch11	7	0.055
Balaju66-16	Siuch13	8	0.084
Balaju66-16	Devighat17	9	0.086
Trisuli18	Balaju66-1	10	0.182
Trisuli18	Devighat17	11	0.006
Siuch13	Patan19	12	0.051
Lekh2	Barat5	13	0.573
Patan19	Ban20	14	0.041

Ban20	Bhakt66-21	15	0.061
N-chabel23	Bhakt66-21	16	0.04
Devighat17	N-chabel23	17	0.144
Balju132-1	Bhakt132-2	18	0.101
Lamos24	Bhakt132-2	19	0.716
Dhalke 25	Khimti 26	20	1.698
Chapur9	Dhalke 25	21	0.245
Khimti 26	Lamos24	22	0.374
Butwal3	Bard4	23	0.318
Bard4	Barat5	24	1.733
Shivpur6	Butwal3	25	1.646
Barat5	Hetaau8	26	0.519
MRS7	Barat5	27	1.758
Siuch11	MRS7	28	0.357
Hetaau8	Chapur9	29	0.851
Hetaau8	Hetau10	30	0.042
Siuch11	Siuch13	31	0.025
Balaju132-1	Balaju66-1	32	0.004
Bhakt132-22	Bhakt66-21	33	0.01
Total Loss			15.212

Figure 4 shows the Loadability curve for the case of INPS with KDTL which clearly shows that by connecting KDTL nose point of loadability curve gets increased and Maximum loading parameter lambda_max in the case of with KDTL reaches to 2.0747.

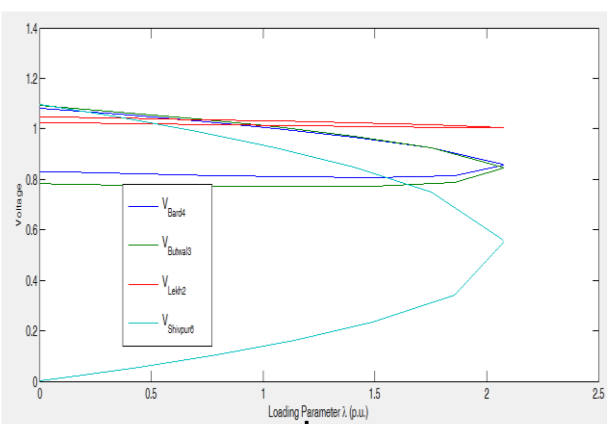

Figure 4: Loadability curve with KDTL

Figure 5 shows the highest power losses in the seven branches without KDTL and the corresponding improvement in loss reduction in these branches after connecting KDTL.

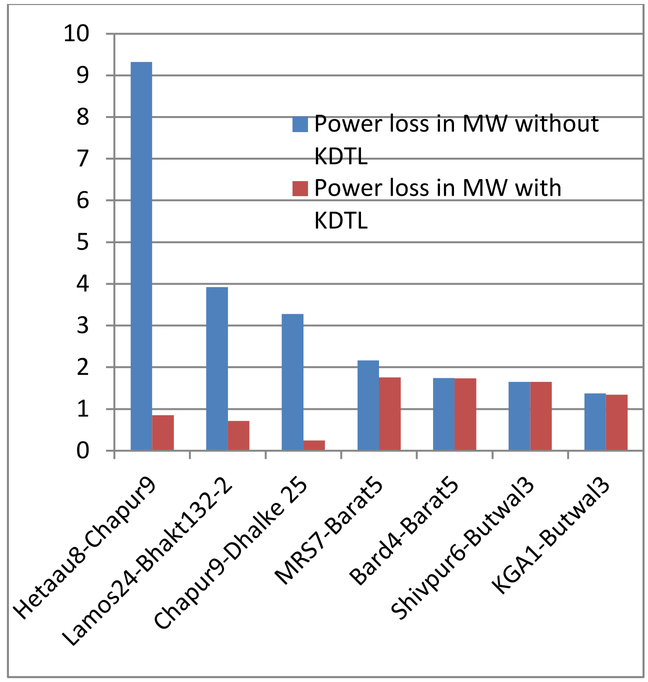

Figure 5: Highest Power losses in the seven branches

The result shows that Transmission loss saving by connecting KDTL to INPS is 15.639MW and energy loss saving per year will be 89048.46 MWh assuming 0.65 loss of load factor. Consuming this saved energy loss by the consumer load there will be income of about NRS 650,053,758.00 per year from the consumer to NEA. From figure 3 and figure 4 it is clear that nose point of loadability curve increases in the case of INPS with KDTL. Maximum loading parameter lambda_max in the case of without KDTL in INPS is 1.2573 whereas Maximum loading parameter lambda_max in the case of with KDTL is 2.0747. Loadability margin is increased by 0.8174 p.u. so voltage stability of the system gets improved.

5. Conclusion

Analysis carried out in this research shows that there is greatly reduction in transmission line power loss of about 15.639MW by connecting KDTL in INPS. And there will be energy loss saving of about 89048.466MWh per year assuming 0.65 LOLF from which NEA can receive income of about NRS 650,053,801.80 per year. Loadability curve in the case of INPS without KDTL from continuous power flow shows that Maximum loading parameter lambda_max is 1.2573 and Dhalkebar bus is the most critical bus whose per unit voltage is only 0.7489 whereas Loadability curve in the case of INPS with KDTL from continuous power flow shows that Maximum loading parameter lambda_max is 2.0747 and voltage profile of Dhalkebar bus which was the most critical bus in the previous case is improved to 0.97024 per unit voltage and Shivpur bus is found critical bus in this case. Analysis shows that there is increase in loadability margin by about 0.8174 p.u. in INPS as a result of commissioning of KDTL so voltage stability of the system is significantly improved. Hence it can be concluded that KDTL should be brought in operation as soon as possible.

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