Optimization of Resources by Integrated Planning of Power System in Nepal

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Abstract: This paper deals with optimization of resources in Power system of Nepal, starting with a review of the present state of the art in the planning, construction and operational practices followed by Concerning body' s, and a discussion of the concept of resource optimization in the field of generation, transmission and distribution under the scope of the future generation, transmission and distribution operations and planning. The particular focus of this research will be in the area of optimization of resources in planning and operational processes. Transmission and distribution networks have been historically planned and operated as almost two separate entities. In Nepalese context, where a large number of hydro potential sites are present, thinking about the distribution system separately from transmission and generation, is a waste of resources by duplication of substation and line. Analysis of a case study in Kabeli corridor found most of the resources duplicate and loss value has large in 33kV line. This paper presents possible layout for integrating generating substation and power evacuation substation with distribution system, and finish with a proposal for reviewing the whole concept of distribution system expansion in future to optimization of resources.

Keywords: Optimization; Resources; Transmission; Distribution; Generation; Planning.

1. Introduction

Nepal, a landlocked country on the northern rim of the South Asia, is bordered by China in the north and India in the south, west and east. Physically stretching 880 km from east to west and 150-200 km from North to South, the country occupies a land area of 1,47,181 sq. km with a population of about 26.5 million at the end of 2011.

Historically, Nepal's power sector has been led by Nepal Electricity Authority (NEA). NEA is the central organization established in 2042 B.S (1985 A.D.) as an undertaking of the Government of Nepal. It is the national organization under the Ministry of Energy which is involved in the generation, transmission and distribution of the electricity in the country and is responsible to make electricity available to all consumers within Nepal through central grid operation.

In Nepal, the first hydropower plant was established at Pharping (500-KW) in 1911, during Prime Minister Chandra Shamsher Rana's time to meet the energy requirements of the members of the ruling class. Transmission line construction was started from second plan which is a Kathmandu-Birgunj 66 KV transmission line and completed on third plan. [3] Today, Nepal has an electric power of total installed capacity 782.451 MW in Integrated Power System. The generated electric power has been transmitted through 132 kV and 66 kV transmission line of 2129.7 km and 511.16 km respectively with 33kV line also. [1] The country has a total substation capacity of 2159.55 MVA to date in 132kV and 66kV voltage level. The generated power thus transmitted to the load center, and by step down the voltage level to reach the consumer end by distribution transformer. Line of 33kV level (Sub transmission lines) is used as power evacuation of small power plants and distribution purposes. Electricity demand in Nepal has been on a rapid increase for many years. Currently, the peak load demand of Nepal is about 1200.98 MW (Nov, 2013). The growth of consumers is also increasing rapidly with the increase in different industries and use of electrical appliances. Annual demand growth presently averaging at 8.5%. Net system losses, including technical and non technical is 24.79% and net annual average consumer's consumption is 1266.62 kWh in FY 2014 [1]. In December 2008 the Nepal Government declared a "national energy crisis".This critical situation is also documented in the last annual report of NEA (FY 2013-14).

Transmission planning must be conducted in coordination with the power generation, according to the location of power generating units and distribution point of view.

Generation, Transmission and distribution planning and operations must be coordinated much more closely in future, and nature of relationship among them as supply and demand meeting, internal consumption. To optimize the resources, framed worked of grid planning must be satisfied.

The power generation and transmission condition under the categories of existing, under construction and planned and proposed are shown in tables below.

Table 1: Generation Scenario

Item	Project	Total Capacity [MW]
Existing Power plant:		
1	NEA Projects	531.24
2	IPP'S	255.647
Sub-Total Existing		787.087
Under Construction:		
1	NEA and NEA's Subsidiary and Associate Companies	1044.10
2	IPP'S	479.306
Sub-Total Under Construction		1523.406
Planned/Proposed or different stage of development:		
1	NEA Projects	1,852.00
2	Power Purchase Agreement with IPP Projects in different Stage of Development	535.445
Sub-Total Planned/Proposed		2387.445
Total		**4697.938**

Table 2: Transmission Scenario

Item	Project	Circuit Length [km]
Existing		
1	132 kV Transmission Lines	2,129.7
2	66 kV Transmission Lines	511.16
Under Construction		
1	132 kV Transmission Lines	972.0
2	220 kV Transmission Lines	373.0
3	400 kV Transmission Lines	570.0
Planned/Proposed or different stage of development		
3	132 kV Transmission Lines	1,540.0
4	220 kV Transmission Lines	1,235.80
5	400 kV Transmission Lines	1,308.0

2. Power system Planning in Nepal

The main objective of distribution planning is to minimize the investment cost, the line loss, and the reliability indices for a study time frame and to support load growth. Generation planning is done in favor to utilize the resources in minimum cost. Transmission planning must be conducted in coordination with the power generation, according to the location of power generating units and distribution point of view.

Generation, Transmission and distribution planning and operations must be coordinated much more closely in future, and nature of relationship among them as supply and demand meeting, in the respect of internal consumption. To optimize the resources, framed worked of grid planning must be satisfied.

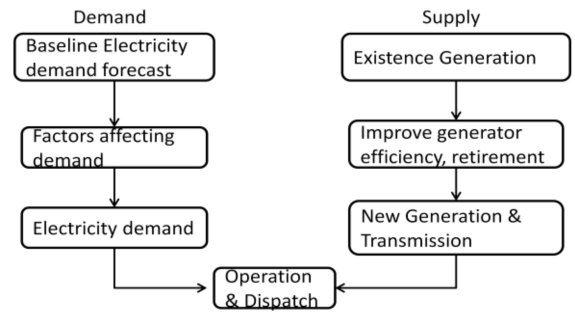

Figure1: Grid Planning Framework

In Nepal, The electricity industry is characterized by vertically integrated utilities. In this scenario utilities could optimize investments because they owned and operated generation and transmission. Although, generation, distribution system is practiced in unbundling case. But due to unbundling, the planning case becomes more complex.

Nepalese, Power system planning was planned generation, transmission, and distribution separately. IPPs are awarded a license wherever they apply for and wish to develop power projects where they have issues the license by Department of Electricity Development. As NEA is solely the transmission line construction authority. IPPs apply for PPA to NEA for connection agreement; therefore NEA should construct the transmission line to evacuate the power. Due to the adhoc licensing of hydropower, basin wise construction couldn't be achieved. The Distribution system was also expanded haphazardly, as a basic need of people, not by quality and reliability only supply and connection is the basic theme. National Planning Commission planned distribution system as political leader interests, not by resource optimization through proper planning.

3. A case study of kabeli corridor: Duplication of Resources

In Mechi zone of Nepal, having four district Jhapa, Ilam, Panchthar, and Taplejung. These districts had planned to electrify by constructing 33kV line. But due to the power evacuation of various projects in this region, the kabeli 132kV Transmission line project (Kabeli Corridor) was started in 2061/062. The objective of this project is to facilitate evacuation of power generated from Kabeli-A Hydro project and other IPPs in the basin. The project will construct substation Hub at Damak, Illam and Phidim to serve the local load. The total cost of this project is estimated to US$ 35.6 Million. Transmission Line (90 km) Double Circuit from Kabeli to Damak and Illam, Phidim, Kabeli Substation Construction will be funded by WB. However Damak S/S construction will be funded by NoG. A project started in 2061/062 (2005/06) and is expected to be completed in FY 2070/71 (2013/014) Damak S/S, 2072/73 (2015/16) 132kV DC Kabeli to Damak Transmission Line and Illam, Phidim Kabeli Substations.

Sub transmission 33kV line of 68 Km were constructed from Anarmani grid substation to Fical substation (1.5 MVA) to Ilam Substation (3 MVA) in 2056 B.S. The same line was extended to Fidim Substaion (3 MVA) having 60Km of length. That line is further extended to Taplejung Substation (1.5 MVA) by 90 Km of length. Altogether that line has a line length of 218Km of 33kV line. The line diagram of the two projects is depicted in figure 2 and 3.

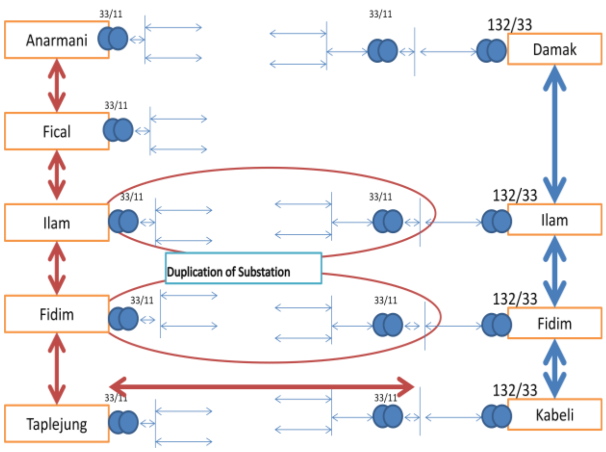

Figure 2: Comparison of 33kV and 132kV line route and duplication of substations

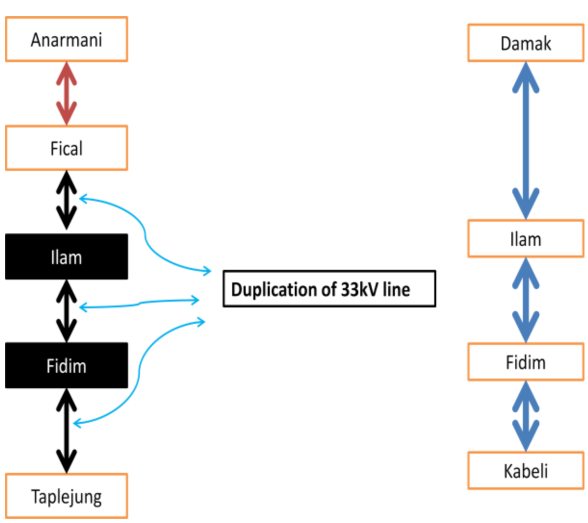

Figure 3: Duplication of 33kV line

In 33kV line the section from fidim to taplejung, only 83km 33kV line construction is complete. Remaining 7Km of 33kV line, construction of 3MVA substation at Taplejung and 33kV bay at Phidim Substaion still yet to be completed.

Now at the present scenario, there are two lines going parallel, which is executed by distribution group and transmission group. From Fig. 2 two numbers of 33/11kV substation at Ilam and fidim becomes duplicate with kabeli corridor. Having 132kV double circuit TL in mechi zone from south to north, 33kV line of 115kM doesn't required because connection between fical to ilam, ilam to fidim and some part of fidim to taplejung section is not require if there is kabeli corridor 132kV TL. Taplejung substation shall be connected from kabeli S/S. In addition to that land acquisition for line and substation, presently, problem faced by the transmission line, becomes duplicate in this case. Therefore, duplication of substation, line, and RoW due to poor planning is verified. The cost associated with this duplication is tabulated below:

Table 3 : Calculation of duplication of resources

SN	Description	Unit	Quantity	Rate	Total
1	Duplication of line	Km	115	1,685	193,775
2	Duplication of 33/11kV substation	Nos.	2	15,300	30,600
3	Right of way Duplication	m^2	230000	1	230,000
Total					454,375

Amounts are in NRs and in thousands

In 33kV line, at fical, Ilam and Phidim there are generation units having total 14MW capacity, due to generation in that area voltage drop problem is not found in Load flow studies. Load flow for both lines is carried out by ETAP, and found loss in 33kV line is 900kW and in 132kV line found loss is 115kW. Difference in loss can be converted to the monetary value, calculation of cost of loss of energy is

Loss in 33kV line=900kW,

Loss in 132kV line= 115kW

Difference in loss=785kW

Loss energy=785x24x365=68,76,600 kWh

Cost of loss energy= NRs. 5,57,00,460

(1kwh=Rs 8.18)

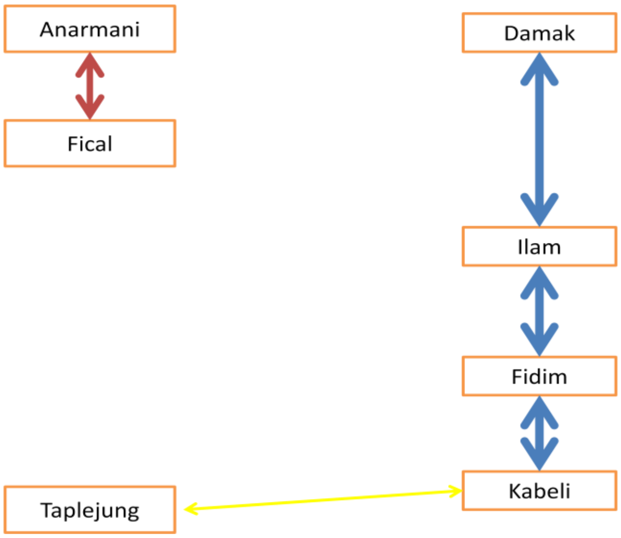

Figure 4: Final configuration of line.

4. Present Scenario and approaches for optimization of resources

As we have, 28 numbers of grid connected power plant, and 23 numbers of isolated HPP owned by NEA and 39 number of IPPs power plant in different sector of Nepal are currently running. There are 11 numbers of under construction project under the subsidiary company of NEA. Now by IPP's there are 62 numbers of HPP are under construction and 48 number of projects are different stages of development of concluding PPA with NEA. Altogether 211 number of projects are presently in operation and in construction phase. Also in Distribution system, various projects, in hilly regions, are under construction phase. Mostly distribution projects are stringing south to northern regions of Nepal by 33kV line and 33/11kV substation. For power evacuation of different HPP, which are under construction, different voltage level line and substation are constructed in different sector of Nepal.

In Far western and midwestern region of Nepal, there are altogether 24 districts. In this region the upper most (Northern) Part has a low population density and high power generation capacity. In this region Nepal electricity authority plan to construct three numbers of 132kV transmission lines for power evacuation of HPP which are listed below:

- Chamelia -Syaule-Ataria 132kV Single Circuit Transmission line project (Under Construction Project)
- Surkhet-Dailekh-Jumla 132kV Transmission Line
- Bajhang-Deepayal-Attariya 132kV Transmission Line

Similarly, In this area, 500km of 33kV line and 8 numbers of 33/11kV substations are existing and 300km of 33kV line and 6 number of 33/11kV substations are in under construction phase. If above mentioned three projects of 132kV line shall be constructed in this area around 80 per cent of 33kV line and 33/11kV substation become useless due to duplication as same as in kabeli corridor.

Most of the power generated project lies in the middle between the south's and north of Nepal. The Potential hydropower site, which are listed in DoED licensing process, approximately 350 numbers of site, some of them are under construction and some of them are PPA concluded is plotted by using GIS, which is shown below in figure 5.

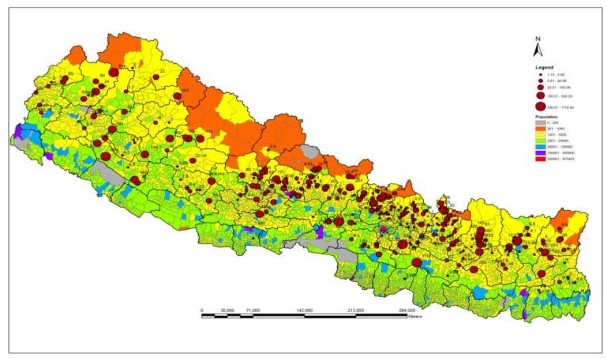

Figure 5: HPP and Population wise map

After plotting a hydropower site location, hilly and mountainous region of Nepal is rich in hydro potential, at least one district has one hydropower capacity in these regions. Approximately 15 districts of Terai region where we already have 132kV transmission line does not have the hydropower potential. Similarly, in distribution system approximately Two dozen of the distribution substation (33kV and 11kV) is now under construction and many substation are under the plan for construction. Same as about 1,000 Km of 33kV lines is under construction for distribution of power in the hilly and mountainous region of Nepal.

If the upcoming hydropower station provides the 33kV and 11kV line for distribution purpose, then the present distribution line of 33kV line from south to north become useless. Therefore the construction of the 33kV line for distribution purposes by making distribution corridor has no meaning and elimination of these results large amount of money will save.

5. Discussion

Nepal, has a large number of hydropower site, in different location, mostly in the hilly and mountainous region. To evacuate the power from these hydropower to grid transmission line should be constructed. Generating station contains the substation for step up the voltage level. As generating station substation incorporates the equipment of distribution voltage level as shown in figure. The concept of the distribution substation close to power houses and power evacuation substation will eliminate the need of 33kV line and its substation in the hilly region of Nepal.

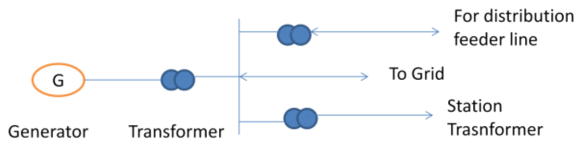

Figure 6: Integration of generation substation for distribution

The concept of the distribution substation integrates in power house substation and power evacuation substation will eliminate the need of 33kV line and its substation in the hilly region of Nepal. By using the this method, loss in distribution line reduced significantly due to reduction of sub-transmission and distribution length. Reduction in length implies reduction in Construction cost also.

6. Conclusion

There are many duplications and redundancies of substation and sub-transmission line in different part of Nepal, due to lack of integrated planning. Huge amount of resources are wasted in the case of kabeli corridor analysis due to poor planning and same could be happening if concerning agencies don't incorporate the issues of resource optimization. To optimize the resources, planning must be done in an integrated way. As in Nepalese contest, where a large number of potential sites for hydropower is scattered all over the country, reviewing the whole concept of distribution system expansion in the future is important for optimization of resources.

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