Limitation on Connecting Mini Hydro Power Plants to the Sri Lankan Power System Network: A Case Study at Balangoda Grid Substation

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Introduction

In 2002 many mini hydro power plants were proposed to connect to the Sri Lankan power system network due to heavy shortage of electricity occurred. Today 60 mini hydro plants (Ceylon Electricity Board, 2006a)are connected to 10 grid substations and further 22 (Ceylon Electricity Board, 2006b) already issued LOI for connection. However, mini hydro plants operations are irregular in two ways. The most effected irregularity is due to faults. The MV lines are more prone for failures. Therefore the mini hydro operation got interrupted several times per months. This causes difficulties to the system operators. The most challenging cases occurred due to a line breaking during heavy loaded conditions and over voltage problems at light loaded operations.

This study is carried out in order to ascertain the implications to the power system network due to the connection of mini hydro power plants. For this study Balangoda Grid Substation is chosen as it has the maximum penetration of mini hydro plants compared to other Grid Substations. This study is based on the data collected at the mini hydro plants connected to the Balangoda Grid Substation. Several power system network loading and mini hydro generating conditions were studied. Limitations of over voltages were found and discussed when large number of mini hydros is integrated at their above 60% capacity (Ceylon Electricity Board, 2006c).

Methodology

The complete Sri Lankan power system which includes the generation & transmission system of 220/132 kV is modeled in IPSA. The 33 kV distribution system is represented by 33 kV lumped loads at each grid substation. The 33 kV feeders at Balangoda grid with mini hydro plants are modeled with mini hydro plants. Rests of the 33 KV systems are represented as loads at appropriate Grid Substations. The system was studied with and without the embedded mini hydro generators under night peak and early morning light loading conditions. Data collection and preprocessing

The mini hydro plants connected to the Balangoda grid substation is shown in Figure 1. Distances of the plant connection from the line and rating of the each mini hydro plant are marked in this Figure.

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The data pertaining to loads and the generation schedule at the night peak and early morning load of 10th May 2006 was fed to IPSA. The effects of connecting mini hydro plants are studied with these loading conditions. The night peak load at Balangoda Grid Substation was 24.2 MW and 9.6 MVAr and there were 11 mini hydro plants which could be connected and capable of delivering maximum amount of 30.0 MW power. The minimum load at Balangoda sub station was 6.4 MW, 2.8MVAr at early morning.

The combinations are from no contribution to full contribution from mini hydros in steps of 20% increasing in generation at night peak & minimum load condition.

Discussion

With the connection of mini hydro plants even with a generation of 60% at peak, voltage of Gomala Oya, Rakwana and Wijeriya bus bars are above the limits. There are about 42 distribution sub stations fed from above and all consumers may experience over voltage. One solution to this is to transfer some loads from adjoining grids to Balangoda grid. Other wise the generation has to be curtailed. At light loading condition, the situation is more severe. Even with a generation of 40% voltage of Gomala Oya, Rakwana and Wijeriya bus bars exceed the limits.

Table 1. Voltage of each bus bar

Bus bar	Voltage for heavy loading(peak loading) and light loading											
	Percentage generation of mini hydro											
	0%		20%		40%		60%		80%		100%	
Balangoda 33Kv	0.998	1.015	1.000	1.016	1.000	1.014	0.999	1.011	0.996	1.006	0.991	1.000
Kuburuthanigala	0.986	1.015	0.991	1.018	0.993	1.018	0.994	1.018	0.993	1.015	0.991	1.011
Belihuloya	0.986	1.015	0.991	1.018	0.994	1.019	0.995	1.018	0.994	1.016	0.992	1.012
Sithagala	0.987	1.015	0.995	1.021	1.000	1.024	1.003	1.025	1.004	1.024	1.004	1.021
Alupotha	0.983	1.015	0.994	1.023	1.001	1.028	1.006	1.031	1.010	1.032	1.011	1.031
Babarathotuwa	0.975	1.015	0.992	1.029	1.005	1.039	1.016	1.048	1.024	1.054	1.030	1.058
Hapugastenna	0.974	1.015	0.991	1.029	1.006	1.041	1.017	1.050	1.026	1.057	1.033	1.061
Way Ganga	0.981	1.015	1.002	1.132	1.017	1.043	1.027	1.043	1.032	1.051	1.032	1.049
Gomala Oya	0.963	1.015	1.004	1.049	1.035	1.074	1.058	1.093	1.074	1.105	1.083	1.111
Rakwana	0.957	1.015	1.006	1.056	1.043	1.084	1.073	1.112	1.094	1.130	1.109	1.141
Wijeriya	0.955	1.015	1.007	1.059	1.048	1.098	1.080	1.121	1.105	1.141	1.122	1.155

Table 2. Line flows and line losses

Bus bar	Fault level MVA		Bus bar	Fault level MVA	
	Without mini hydros	With mini hydros		Without mini hydros	With mini hydros
Balangoda 33Kv	1092.754	1266.835	Hapugastenna	108.703	311.607
Kuburuthanigala	237.011	332.148	Way Ganga	161.137	367.976
Belihuloya	211.293	290.604	Gomala Oya	75.772	219.822
Sithagala	255.557	366.773	Rakwana	59.127	193.199
Alupotha	194.951	321.661	Wijeriya	52.796	235.994
Babarathotuwa	116.764	286.510			

Table 3. Fault level

Bus bar	Fault level MVA		Bus bar	Fault level MVA	
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Fault level of Balangoda grid is increased by 16% by connecting the mini hydro plants. Breakers at the grid at 33kV level have a short circuit capacity of 1450 MVA. Hence at this moment it is not a problem. If any other plants to be connected the switch gear of Balangoda grid sub has to be changed.

The line losses due to the connection of the mini hydro plants have been increase by 3 MW. This is very significant as it was 0.14 MW with out mini hydros. The line losses of 132 kV side has increased by 1.22 MW by connecting the mini hydro plants. It is 37% increase over the losses without mini hydro plants.

Conclusions

At Balangoda grid, mini hydro plants penetration is studied. This has shown that the voltages at the mini hydro plants terminals have already exceeds the limits with above 60% injection at night peak loading conditions. Further over voltages occurred in several points at light loading condition. This has also increased the fault level at the grid substation by 16%. Therefore this study concludes that for proper utilization of mini hydro plants, a voltage control mechanism must be adopted at the grid.

References

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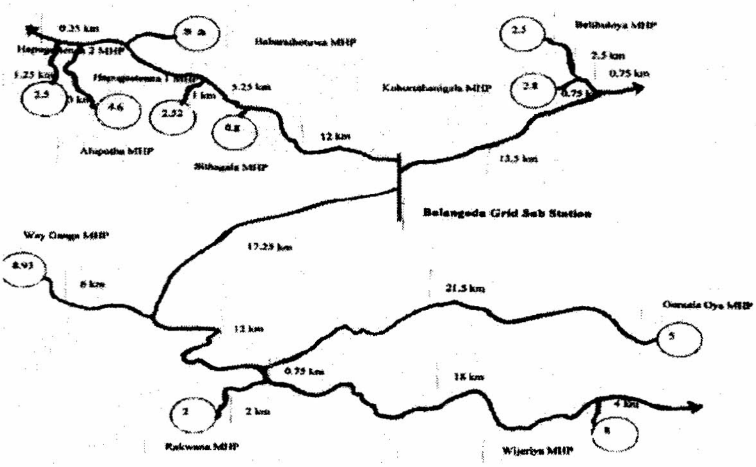

Figure 1. Mini hydro plants connected to Balangoda grid substation