PUMPED STORAGE POWER PLANT FOR SRI LANKA- A CASE STUDY ON ELECTRICITY TRANSMISSION ASPECTS

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Introduction

A Pumped Storage Hydro Power Plant (PSPP) is the best possible option to handle the peaking scenario in Sri Lankan transmission system due to the following reasons. Sri Lanka has a fluctuating daily load pattern, where it records a sharp peak in the demand of electricity during 1830-2130 hours. This peak demand only occurred 12.5% (3 hours) of a day, the period the network is fully utilized. Therefore a serious analysis is required to handle this peak demand in the electricity which burdens the national economy, where PSPP can play major role on flattening the demand. The Sri Lankan electricity system is projected to be coal dominant by 2020, so that pumping energy can be provided by coal power plants during off peak hours and most of the energy will be recovered by the motoring operation of PSPP, to cater to the night peak demand. An additional benefit will be increasing the load factor of the coal power plants, flattening the load curve thus increasing the utilization of the entire transmission network in 2020. The Ceylon Electricity Board (CEB) had done a preliminary study on PSPP in Sri Lanka, where eight candidate sites have been selected (CEB, 2009). Among them, one very attractive site has been identified in the Kiriketi-Oya vicinity, north of Samanalawewa reservoir in Haputhale, at the central region of Sri Lanka (CEB, 2009). This power plant is proposed to be connected directly to Kotmale Power Station using 220kV double circuit transmission line (CEB, 2009). This research has mainly focused on checking the feasibility of Kiriketi PSPP, where it is to be interconnected to the Sri Lankan transmission network in the year of 2020.

Details of the study

The entire transmission network of Sri Lanka in 2020 was built using Integrated Power System Analysis (IPSA) software package where Kiriketi PSPP was incorporated into the system. In order to check the feasibility of the 2020 network, the system studies were carried out under normal operating conditions, that is especially the load flow analysis and studies under contingencies as well.

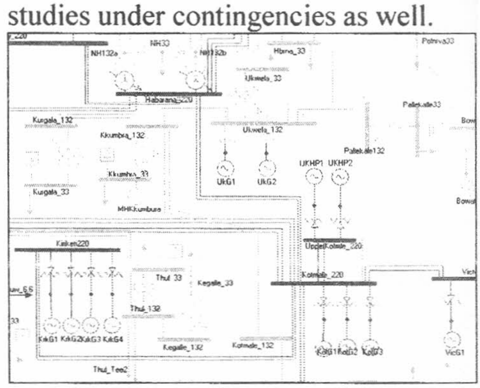

Fig. 1. Kiriketi PSPP consuming power from the grid

Here a unique case has been considered to ensure quality and reliable power supply with the interconnection of Kiriketi PSPP in

2020. That is to check whether it is feasible to use coal power from Trincomalee and Nuraicholai with the entire transmission network in Sri Lanka to pump water in Kiriketi PSPP. This is specially done during off peak hours where the coal power generation will be more than the base load. This transmission network in 2020 was built using the IPSA software package and feasibility of this power plant has been checked.

Load Flow Analysis

This paper specifically includes only load flow analysis under Night Peak Hydro Maximum (NPHM) and Day Peak Thermal Maximum (DPTM) conditions of the above special case with the inclusion of Kiriketi PSPP. One of the generator bus bar in Kotmale has been taken as the slack bus bar for calculation purposes. Here the transmission network equipment parameters were taken into a common base of 100 MVA and frequency of the entire network was specified as 50 Hz. The load flow results of the converged system were obtained and important results are tabulated which ensure quality and reliable power supply.

Table. 1. Comparison of voltage rating exceptions in 2020

Initially the voltage rating exceptions were studied and the results are shown in table-1, where a stable system can be obtained quickly by removing the above exceptions by correctly positioning Mechanically Switched Capacitors (MSCs) in affected bus bars.

Bus bar	Voltage/pu
Havlok132	0.798
Panni_132	0.782
Pdura_33	0.791
ApuraNew	0.587

From the simulation studies, the transmission loss of the whole network with the interconnection of Kiriketi PSPP was calculated under special conditions and tabulated in table-2.

Table 2. Transmission Losses

	Condition	Transmission Loss/ MW
Option 1	NPHM	284.052
2020	DPTM	129.394

Finally, the number of overloading conditions of the network was observed. Mainly Oruwella, Ratmalana, Nuwara-Eliya, Kolannawa, Panadura, Galle, Matugama, Dehivala, Jayawardanapura, Bolawattha, Embilipitiya, Kurunegala and Ratnapura feeder transformers were overloaded. Hence augmentation of the existing grid can be achieved by introducing a transformer with the typical rating of 31.5 MVA with the existing system. Further Kotugoda (132/33 kV), New Anuradapura (132/33 kV), Veyangoda (220/132kV) tertiary transformers were overloaded. Hence new Grid Sub Station (GSS) must be introduced to cater the excess demand.

The above overloading conditions were solved by a conventional methodology. That is if an overloading condition occurs the excess load can be transferred to the nearest GSS or can augment the existing GSS or can introduce a new GSS [CEB, 2009]. Likewise the overloading conditions were identified and removed by above measures. These measures can be selected according to necessity and also considering the expenditure.

Fault Level Analysis

Three phase symmetric RMS Line-line-line fault calculation was carried out with a fault time of 100 ms under NPHM conditions.

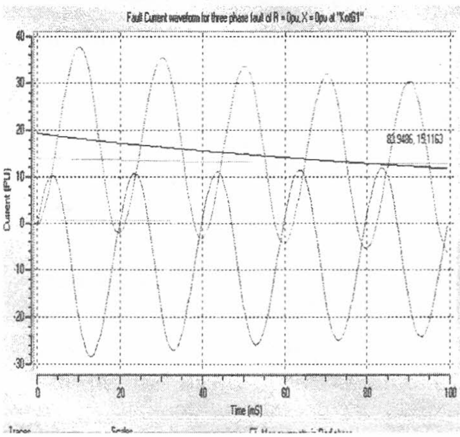

Fig. 2. Waveform of 3 phase fault current during LLL fault in Kiriketi 220 kV bus bar

Fault level results indicates that the proposed PSPP will require a circuit breaker with a peak make rating of 107 kA, RMS break rating of 40 kA and DC break rating of 55 kA for a 500 MW rated Kiriketi PSPP.

Table-3 shows a simple comparison of fault currents with the existing system for some selected bus bars. This study has been conducted to ensure whether each and every transmission line is protected by their respective circuit breakers.

Table.3.Comparison of Fault Currents in selected elements

Busbar / Branch	Fault Current/ kA
Kiriketi Busbar	10.571
Biyagama-Kotmale	11.922
Kiriketi-	11.958
Biyagama-Kotugoda	16.560

Discussion and Conclusion

This study yields that interconnection of Nuraicholai and Trincomalee coal power plants with the entire transmission network in 2020 is essentially required to pump water in Kiriketi PSPP when considering only technical aspects. That is especially (i) checking of voltage rating exceptions (ii) the transmission losses under normal operating conditions and (iii) the results on fault level analysis. This confirms that the system with proposed PSPP is more reliable under the contingencies studied in this paper.

References

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