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Effects of Bilateral Transactions on the System Reliability

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ABSTRACT

Background: Power system reliability is an important and major issue in the power system planning and operation. This issue has been widely investigated and evaluated from different views and aspects and it is really necessary to assess the system reliability for long term plans. **Objective**: This paper aims at assessing the reliability under deregulated electricity market environment. In this regard, this article evaluates the effects of bilateral transactions on the system reliability. **Results**: A standard power system is considered as test case and system reliability is assessed following bilateral transactions. The reliability indexes are calculated and evaluated following several conditions. **Conclusion**: The simulation results denote the significant effects of bilateral transactions on the system reliability.

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INTRODUCTION

Today's electricity distribution systems operate in a liberalized market. These systems should therefore be able to provide electricity to customers with a high degree of reliability and be cost-effective for suppliers. Paper (Yssaad *et al*., 2014) provides a discussion of the two primary objectives of RCM: to ensure safety through preventive maintenance actions, and, when safety is not a concern, preserve functionality in the most economical manner. For the power distribution systems facilities, the mission should be considered at the same level as safety. Paper (Johansson *et al*., 2013) provides a reliability and vulnerability analyses of critical infrastructures and compares two approaches in the context of power systems. This paper discusses that society depends on services provided by critical infrastructures, and hence it is important that they are reliable and robust. Two main approaches for gaining knowledge required for designing and improving critical infrastructures are reliability analysis and vulnerability analysis. The former analyses the ability of the system to perform its intended function; the latter analyses its inability to withstand strains and the effects of the consequent failures. The two approaches have similarities but also some differences with respect to what type of information they generate about the system. In this view, the main purpose of this paper is to discuss and contrast these approaches. To strengthen the discussion and exemplify its findings, a Monte Carlo-based reliability analysis and a vulnerability analysis are considered in their application to a relatively simple, but representative, system the IEEE RTS96 electric power test system. The exemplification reveals that reliability analysis provides a good picture of the system likely behavior, but fails to capture a large portion of the high consequence scenarios, which are instead captured in the vulnerability analysis. Although these scenarios might be estimated to have small probabilities of occurrence, they should be identified, considered and treated cautiously, as probabilistic analyses should not be the only input to decision-making for the design and protection of critical infrastructures. The general conclusion that can be drawn from the findings of the example is that vulnerability analysis should be used to complement reliability studies, as well as other forms of probabilistic risk analysis. Measures should be sought for reducing both the vulnerability, i.e. improving the system ability to withstand strains and stresses, and the reliability, i.e. improving the likely behavior. Paper (Safdarian *et al*., 2014) discusses that recent investigations have revealed the significant role of reactive power in blackout events. The associated disturbances frequently emerge in the form of voltage instability and collapse. Due to the computational complexity of modeling and analysis of enormous contingencies, DC approximation of the power flow, without accounting the role of reactive power, is usually used to evaluate the contingencies and to mitigate the associated probable violations. Paper (Safdarian *et al*., 2014), at first, presents a linear power flow model based on an approximated version of AC power flow formulation. The proposed

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model is then used to develop an efficient reliability assessment approach which is capable of taking both active and reactive powers into account. The analysis technique is based on the linear programming format which leads to an optimal solution within a short computation time. Voltage and reactive power violations as well as transmission system overloads are alleviated by generation rescheduling or load shedding as the last resort. Paper (Lin *et al*., 2014) explains that wind energy has been considered as an important substitution of fossil-based energy for future society. However, large-scale integration of wind power will introduce great risks to both power system planning and operation due to its stochastic nature. By adopting power system reliability theory, the risks can be quantitatively estimated so that numerous publications have been published to study reliability impacts caused by wind power. This paper thoroughly investigates the features of existing reliability models of wind power, reliability assessment algorithms and its applications in wind power related decision making problems. The paper also reveals significant differences existed in reliability models and algorithms between planning and operational phase of power systems, which are neglected in existing review articles.

This paper aims at assessing the reliability under deregulated electricity market environment. In this regard, this article evaluates the effects of bilateral transactions on the system reliability. A standard power system is considered as test case and system reliability is assessed following bilateral transactions. The reliability indexes are calculated and evaluated following several conditions. The simulation results denote the significant effects of bilateral transactions on the system reliability.

Methodology:

Bilateral Transactions:

A bilateral contract in an electricity market is an agreement between a willing buyer and a willing seller to exchange electricity, rights to generating capacity, or a related product under mutually agreeable terms for a specified period of time. Most economists agree that such arrangements are crucial to the functioning of electricity markets, because they allow both parties to have the price stability and certainty necessary to perform long-term planning and to make rational and socially optimal investments (Hausman *et al*., 2008). To design an efficient transmission tariff, recently transmission pricing has become one of major research topics in power industries. From the economic point of view, estimate of accurate costs is needed to provide the correct price signals. Paper (Baniya *et al*., 2005) aims to present a transmission pricing methodology for bilateral transactions in a voluntary net pool under competitive environment. To demonstrate the effectiveness of the proposed transmission pricing method, an IEEE 30-bus RTS system and integrated Nepal power system (INPS) consisting 58 buses, 18 generators, and 91 branches have been used for numerical simulation.

Test System:

In order to assess the effects of bilateral transactions on the system reliability, a six-bus test system is considered as case study and this system is depicted in Figure 1. The system data are listed at Tables 1 to 3. The bilateral transaction is also defined as 40 MW contract between generator at bus 6 and load at bus 5 and this power is transferred through direct line between the proposed buses.

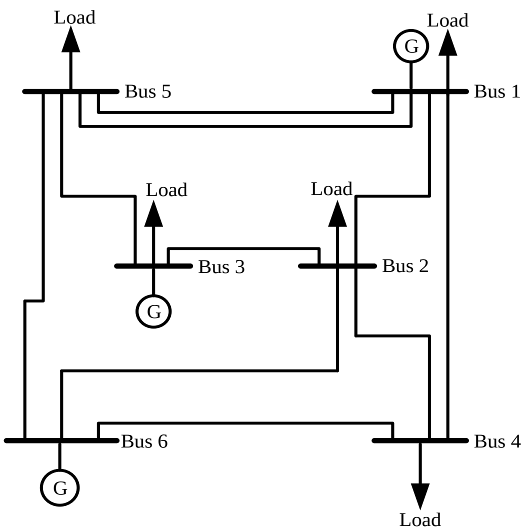

Fig.1: Six bus test system.

Table 1: The generators data of six-bus test system.

Bus	Type	P_D [MW]	Q_D[MVar]	P_G^{max}[MW]	P_G^{min}[MW]	Q_G^{max}[MW]	Q_G^{min} [MW]
1	VΘ	80	16	200	0	50	-10
2	PQ	240	48	-	-	-	-
3	PV	40	8	400	0	100	-10
4	PQ	160	32	-	-	-	-
5	PQ	240	48	-	-	-	-
6	PV	0	0	600	0	180	-10

Table 2: The branches data of six-bus test system.

Bus From	Bus To	r_{ij}[p.u.]	x_{ij}[p.u.]	b_{ij}^{sh} [p.u.]	s_{ij}^{max}[MVA]
1	2	0.040	0.400	0.00	120
1	3	0.038	0.380	0.00	120
1	4	0.060	0.600	0.00	100
1	5	0.020	0.200	0.00	120
1	6	0.068	0.680	0.00	90
2	3	0.020	0.200	0.00	120
2	4	0.040	0.400	0.00	120
2	5	0.031	0.310	0.00	120
2	6	0.030	0.300	0.00	120
3	4	0.059	0.590	0.00	120
3	5	0.020	0.200	0.00	120
3	6	0.048	0.480	0.00	120
4	5	0.063	0.630	0.00	95
4	6	0.030	0.300	0.00	120
5	6	0.061	0.610	0.00	98

Table 3: The system data for market studies.

Bus	MW offer	Offer Price [$/MW]
1	200	9
3	400	20
6	600	15

Results:

The proposed bilateral transaction is simulated on the test system and simulation results are listed at Table 4. In addition, the results without the proposed bilateral transaction are also listed at Table 4. It is clear that the proposed bilateral transaction has a great effect on the system reliability. The independent system operator (ISO) can uses several bilateral transactions to provide suitable performance at the network.

Table 4: The system reliability indexes.

	without bilateral transaction	with bilateral transaction
LOLE (h/year)	25.11	28.92
EENS (MWh/year)	195.21	204.94

Discussions:

The bilateral transactions have a great effect on the system performance as well as reliability. In the bilateral transactions, the generations, loads, and transmission lines that are associated with transactions provide more constraints in the OPF problem and therefore new results are obtained. The results show that bilateral transactions are important and should be considered and evaluated in power system analysis such as reliability assessment.

Conclusions

The effect of bilateral transactions on the system reliability was investigated in this paper. IEEE six-bus power system was considered as test case and the effect of bilateral transactions on reliability was evaluated. Several reliability indexes such as LOLE and EENS were calculated and evaluated. The results showed the significant effect of bilateral contracts on the system reliability.

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