한전 765KV 송전선로 확충계획의 확률론적 신뢰도 평가

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Probabilistic Reliability Evaluation for 765KV Transmission Lines of KEPCO Grid Expansion Planning

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Abstract - The importance and necessity conducting studies on grid reliability evaluation have been increasingly important in recent years due to the number of black-out events occurring through in the world. Quantity evaluation of transmission system reliability is very important in a competitive electricity environment. The reason is that the successful operation of electric power under a deregulated electricity market depends on transmission system reliability management. Also in Korea it takes places. This paper presents the probabilistic reliability evaluation for 765KV transmission lines of KEPCO grid expansion planning. The Transmission Reliability Evaluation for Large-Scale Systems (TRELSS) Version 6.2, a software package developed by Electric Power Research Institute (EPRI) is utilized in determining the improved probabilistic reliability indices of (KEPCO) system.

1. Introduction

The importance and necessity of conducting studies on grid reliability evaluation have been increasingly important in recent years due to the number of black-out events occurring through in the world. Bulk transmission systems are planned to meet specified criteria in an attempt to provideconsistently high reliability for utility customers. One very important requirement in the planning and operation of a bulk power system is maintaining reliability of service to the loads. Planning engineers are interested in representing systems in as much detail as possible and in studying as many contingencies as possible, using accurate power flow algorithms [1].

Korea power system is aiming to smash up the monopolies utility, which have been "regulated" by the government, and create a competitive electricity generation market as the first step going to deregulated electricity market in the future. Their targets are not only increased competition, increased outside investment in power system infrastructure and application new technology utilization in generation zone, but also to meet the expected growth of power demand at the highest reliable. Therefore, KEPCO has decided to separate six generating companies (GENCOs) from the KEPCO generation assets. And so, KEPCO will own the grid system and distribution system. Hence, the expansion plan and reliability evaluation of transmission system are one of the most important task's KEPCO now. A project on the probabilistic reliability evaluation of KEPCO system using TRELSS V.6_2 has been conducted [2]. The TRELSS program has demonstrated the merits and demerits with KEPCO system [12].

This paper evaluates to impact on probabilistic reliability evaluation of 765KV transmission lines into KEPCO grid. The diverse reliability indices of bulk system present important role of each 765KV line which impacts on reliable to deliver the electric energy to customers of grid when it is in-service (scheduling, maintaining, etc). The TRANSCO's owner not only makes decision to maintain 765KV lines but also to expand a grid based on reliable system management. The grid expansion planning has been predicted several years from 2006 to 2010 for meeting expected growth of power demand in that year respectively.

The approach was utilized a *capability approach* which enumerates the deeper failure state as well as failure and success state. Remedial action is required practically in real power systems. In the capability approach, remedial action such as load shedding alleviates system problem. The Transmission Evaluation for Large Scale System (TRELSS) used as the tool in this paper. The capabilities, major applications and characteristic of TRELSS have been demonstrated past time [9]-[14].

2. TRELSS Operational Process For Probabilistic Reliability Evaluation

TRELSS can accept input data file from either an IEEE or PTI or EPRI converter IEEE PSADD formatted load flow file. However, KEPCO has been using PSS/E for operating at Korea power system. Therefore, this load flow data file, which will be applied convenient for reliability evaluation by using TRELSS, is PTI formatted for actual system. The operational TRELSS process from PTI format can be shown at Fig. 1.

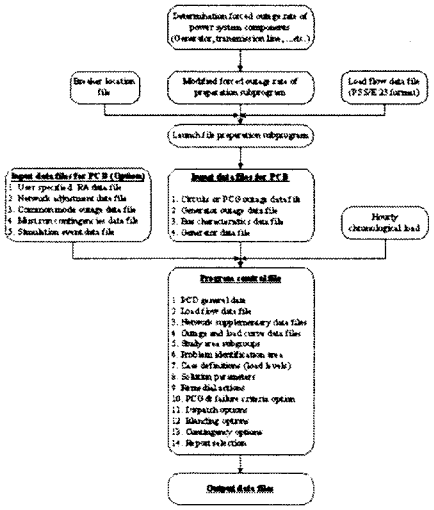

Fig. 1 operational TRELSS process

3. KEPCO Configuration System

The paper has tested on KEPCO system configuration in 2006 as the base case. The KEPCO system has about 1668 buses, 1948 circuitsand 858 transformers as shown at Fig.2. The annual chronological record of hourly loads of KEPCO system was used for the load variation curve input data as shown at Fig. 3. Moreover, the scenarios of load in KEPCO system reached the peak load at summer, because at that time it is hot so air-condition operations. The electricity demand for KEPCO system has been long-term predicted as shown in Fig.4. The outage component of system for input data of preparation as shown at Table 1.

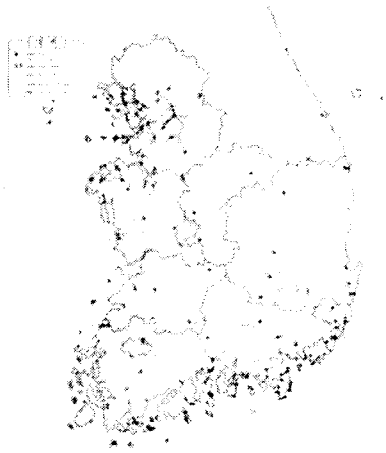

Fig.2 KEPCO power system configuration

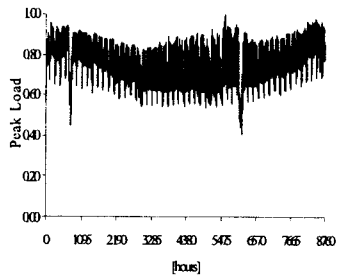

Fig.3 Scale load variation curve of KEPCO system

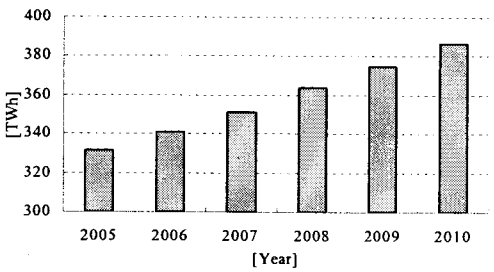

Fig. 4 Predicted annual energy demand of KEPCO system

Table 1. Outage Input Data of Case Study System

Items [uint]	Outage input data
TOT_OUT/YR [occ./year]	0.0001
TOT_HRS/OUT [hours/occ.]	2.5
WEATH_OUT/YR [occ./year]	0.001
WEATH_HRS/OUT [hours/occ.]	2.5
MAINT_PROB	0.01
MAINT_HRS/OUT [hours/occ.]	8.0
GEN_FO_PROB	0.01
GEN_FO_HRS/OUT [hours/occ.]	10.0
PCG_SC_OUT/YR [occ./year]	4.0
PCG_SC_WEATH_OUT/YR [occ./year]	3.0
PCG_SC_HRS/OUT [hours/occ.]	0.5
PCG_SC_ WEATH_HRS/OUT [hours/occ.]	0.5

4. Case studies

The contingency depth has used N-3 which is checked one generator and two transmission lines fail. The load flow in 2006, which has seven 765KV lines, is the base case. The total power supply and peak load are 61490MW and 53024MW respectively. The load flow in 2010, which has nine 765KV lines, has planed expansion system. The total power supply and peak load are 73424MW and 60133MW respectively.

The first case is simulated with load flow of KEPCO system in 2006. The various reliability indices of bulk system present impact of in-service of each 765KV on the bulk system. Especially, the transmission line from Dangjin TP to Sin Seosan is the most impact on reliable delivery electric energy of bulk system to the load points. On the other hand, the transmission line from Sin Anseong to Sin Seosan is less impact as shown at Table 2.

Table 2.System reliability indices of each line in-service at forecasting load flow 2006

From Bus	Bus Name	To Bus	Bus Name	CKT	LOLE [hr/yr]	EENS [MWh/yr]
1020	Sin Gapyeong	4010	Sin Anseong	1	273.0	18146.53
1020	Sin Gapyeong	5010	Sin Taebaek	1	255.02	16569.33
1020	Sin Gapyeong	5010	Sin Taebaek	2	255.02	16569.33
4010	Sin Anseong	6030	Sin Seosan	1	18.91	1263.84
4010	Sin Anseong	6030	Sin Seosan	2	18.91	1263.84
6020	Dangjin TP	6030	Sin Seosan	1	280.69	17908.07
6020	Dangjin TP	6030	Sin Seosan	2	280.69	17908.07

The second case is used load flow of KEPCO system in 2010 which will be installed two 756KV lines from Buk-Kyungnam to Go-ri to reach the predicted load demand. The all most of reliability indices of bulk system are lower than the fist case. The variation gap of reliability indices of bulk system between each line in-service is small that means the role of each line into the grid to be shared equally as shown at Table3, Fig. 5 and Fig. 6.

Table 3.System reliability indices of each line in-service at forec asting load flow 2010

From Bus	Bus Name	To Bus	Bus Name	CKT	LOLE [hr/yr]	EENS [MWh/yr]
1020	Sin Gapyeong	4010	Sin Anseong	1	119.95	6292.45
1020	Sin Gapyeong	5010	Sin Taebaek	1	115.76	6020.60
1020	Sin Gapyeong	5010	Sin Taebaek	2	115.76	6020.60
4010	Sin Anseong	6030	Sin Seosan	1	159.15	7360.69
4010	Sin Anseong	6030	Sin Seosan	2	159.15	7360.69
6020	Dangjin TP	6030	Sin Seosan	1	132.61	7382.27
6020	Dangjin TP	6030	Sin Seosan	2	132.61	7382.27
8010	Buk -Kyungnam	9010	Go-ri	1	108.54	6174.81
8010	Buk -Kyungnam	9010	Go-ri	2	108.54	6174.81

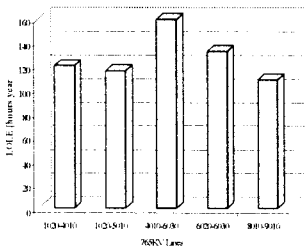

Fig. 5 LOLE of bulk system when each line in-service

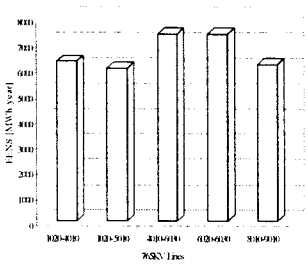

Fig. 6 EENS of bulk system when each line in-service

5. Conclusion

This paper presents the results from several case studies on the KEPCO system using TRESS. This paper also illustrates the importancerole of each 765KV transmission line to impact on reliable delivering electric energy to load points. The sensitivity analysis of results introduce the importance role of addition two 765 transmission lines into the grid in 2010 as like as the probabilistic reliability evaluation for 765KV transmission lines of KEPCO grid expansion planning. Sensitivity analysis for case study shows that TRELSS is an effective tool for reliability evaluation of composite power system. We hope that the results can supply scenariosof 765KV transmission line expansion planning to owner/planner of TRANSCO to make decision for planning, operating and management reliability of bulk system.

Acknowledgements
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