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대단위 풍력발전단지의 과도 안정도 특성에 관한 연구

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Effect of a large-scale wind farm on power system transient stability

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Abstract - Wind power is one of the fastest growing distributed generation types. As part of a worldwide trend, the concerns of large wind generation have been risen rather than small wind generation since it influences the whole power system including the transient stability.

The objective of this paper is to understand the effect of a large-scale wind generation on power system transient stability and to develop a systematic procedure to assess the effect according to the location and capacity of a wind farm. In the proposed procedure, an index is presented to evaluate the appropriateness of the location and capacity of a wind farm for transient stability contingencies.

1. INTRODUCTION

Recently, the renewable energies are being interested and developed to solve the shortage of fossil resources and the environmental problems. Comparatively speaking with fossil resources, the most of the renewable resources such as sun power and fuel cell are economically poor as yet. However, many of the wind power have been operated and come into wide use in EU. Based on the fact that the development of large capacity wind generator, the economic assessment of the wind power is highly valued. After all, now in these days, the large wind power is widely spread all over the world.

It is accelerated to build the large capacity generator of the wind power. When the penetration of wind power is low, influences of the wind energy on the power system may be trivial. However when the penetration of wind average increases, its influence is not limited to the small network but starts to influence the whole system.

In the South Korea, a plenty of electric power mostly depend upon the fossil and the nuclear resources. There are wind powers in Daegwallyeong and island of Jeju but these aren't the large capacity wind generator. To increase the number of large wind power, some companies unionized 'Offshore Wind Power Forum', as described in [1].

Specific conditions are required to Determinate the location of the wind farm. First of all, it should be mentioned that the sufficient amount of wind is existed. Especially the place which is windy all the year round is the best place ever. After checking the amount of the wind, the environmental conditions should be investigated. However, although these conditions fully satisfied, transient stability should be carefully considered. For the purpose of a good stability in contingency, the power system including the wind power should be stable in any external conditions, and this must be checked before the final determination. If the selected place satisfies with all of these requirements, then the wind power can be built on it. It is interesting to note that in order to build the large wind farm, a site of one will be planned for connection to weak electrical systems to avoid instability of the network [2].

This paper presents the procedure to suggest how to select the location of wind farm and compare one to others to lay out relative merits.

2. RESEARCH APPROACH

2.1 Framework of the study

The location of wind farm is restricted by wind condition. In this paper, three locations are analyzed. Those are possible to install the large scale wind farm. Considering an installation of wind farm in the western sea, the 'Taean' is chosen at first. The second location is 'Hoenggye'. It is based on the fact that a small scale wind farm is currently in existence and more large wind farm is expected to install. Expecting the installation of a large offshore wind farm, third location is decided 'Pohang'. In this paper, the objective is to suggest the procedure how to select the wind farm locations which have better transient stability.

2.2 Simulation scenarios

2.2.1 Step 1

First of all, an amount of wind power needs to be decided. In the close future, it is expected that 1000MW wind farm is installed in KEPCO(Korea Electric Power Corporation) system. Therefore the capability of wind farm is chosen 1000MW. There are three cases in step 1 simulation. In case 1, 1000MW wind farm is installed in 'Taean'. This voltage level of connection is 154kV. Simulation is performed for the severe contingency, generator drop. It is based on the fact that the wind generation depends on wind speed characteristic. If the wind speed is very low, wind farm can not generate power. In this situation, wind farm takes no effect. In case 2, same method is applied in 'Hoenggye'. In case 3, same simulation is performed in 'Pohang'. In this study we assess the security with simulation result. If the result is secure, we distinguish a relative superiority using transient stability index.

2.2.2 Step 2

In step 2, it is interesting to note that distribution of wind power capability. Total 1000MW power is properly distributed on three selected locations. And it is need to finding the optimizing distribution. A criterion on optimizing is the best stable condition considering transient stability[3]. Transient stability of the system is assessed by N-1 route contingency analysis of the 345kV transmission line around the selected sites of the wind farm. Based on the result the case which shows best transient performance is selected and an amount of dispatch of each location is determined. This step 2 will proceed in the following case in Table 1. Total 22 cases were simulated. Each case needs proper readjustment of generation.

<Table 1> Distributed amount of generation

Case #	Taean(MW)	Hoenggye(MW)	pohang(MW)
1	0	0	1000
2	0	200	800
3	0	400	600
4	0	600	400
5	0	800	200
6	0	1000	0
7	200	0	800
8	200	200	600
9	200	400	400
10	200	600	200
11	200	800	0
12	400	0	600
13	400	200	400
14	400	400	200
15	400	200	400
16	400	0	600
17	600	400	0
18	600	200	200
19	600	0	400
20	800	200	0
21	800	0	200
22	1000	0	0

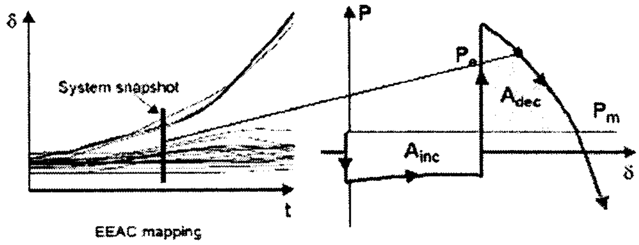
2.3 Simulation setup

The 2010 summer peak KEPCO power system is used in this paper. The detailed information is in table 2.

<Table 2> 2010 KEPCO power system

BUS	Peak power(MW)	branch	Generator
1869	61,900	3188	304

In this paper, transient stability index is described as seen in Fig. 1[4].



<Figure 1> Transient stability index

If the system is stable, ($A_{dec} > A_{inc}$)

$$i = 100 \times \frac{A_{dec} - A_{inc}}{A_{dec}}$$

If the system is unstable, ($A_{inc} > A_{dec}$)

$$i = 100 \times \frac{A_{dec} - A_{inc}}{A_{inc}}$$

3. Studies of the KEPCO case

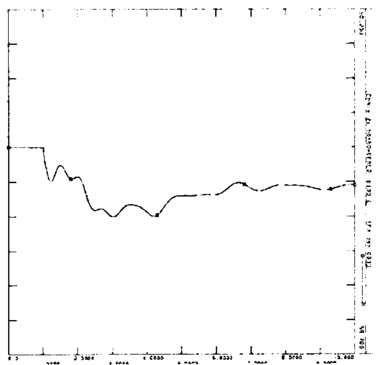
3.1 Step 1

Step 1 simulation is performed on the severe 3 case

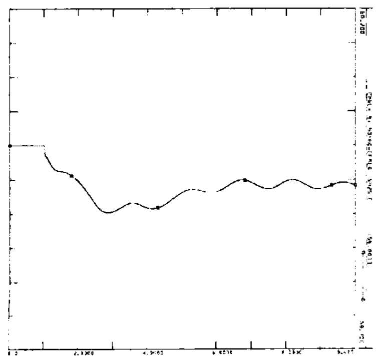
<Table 3> Step 1 case

	Taean(MW)	Hoenggye(MW)	Pohang(MW)
case1	1000	0	0
case2	0	1000	0
case3	0	0	1000

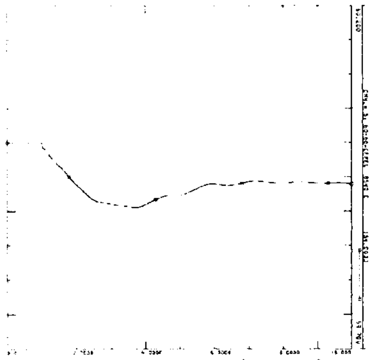
A method of drop unit is used in contingency[5]. At 1 second, wind farm is dropped. The frequency is presented in fig 2,3,4.



<Figure 2> Case 1(Taean)



<Figure 3> Case 2(Hoenggye)



<Figure 4> Case 3(pohang)

As seen in Fig, 2-4, All of the 3 case were stable. Considering the oscillations which happens after contingency, case 3 was more stable than case 1. It was based on the fact that the power system including 'Pohang' was stronger. In the neighborhood of 'Pohang', a many large scale generator was existed.

3.2 Step 2

The 22 case were divided two groups by the result of step2 simulation. The first group was the stable case, which was less than 10 of unstable contingencies among 62 contingencies.

<Table 4> Step 2 result

State	case
secure	1,2,3,4,5,6,7,9,10,11,22
insecure	8,12,13,14,15,16,17,18,19,20,21

In case of 3, most of contingencies were stable. On the contrary, the case 20 was serious unstable. Generally, distributing the amount of generation affected the stability of the total system. If the 'Taean' is larger, then it becomes unstable. But if the 'Pohang' is larger, then it becomes stable. This result is caused by differences of surrounding power system. What it means, Pohang's surrounding power system is much more secure than Taean's. As total system of 'Taean' is weak, if who want to build wind farm on west coast of South Korea like as 'Taean', then the safety of the total power system must be checked before built. The variation of wind farm is very large, so that to find the way of securing the stability of total system is very important.

3. Conclusions

In this paper, wind farm site selection procedure using transient stability index has been presented. The first, stability had been checked in case of the large wind farm inserting with designated locations. If the system is unstable, it looses its consideration. But if there were 2 or more stable locations, a selection of the superior one is need. By the base of the result processed, simulation had performed to find out the best lay out of the power distribution. N-1 route contingency analysis of the 345kV transmission line is used in this simulation. The suitable location of the wind farm can be estimated by choosing the better transient stability, which the way suggested in this paper.

[참 고 문 헌]

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