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Generation Management Through Sensitivity Factors For A Dg Installed Power System

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Abstract: *Generation Management (GM) plays a vital role for the increased demand in the power system. GM has to be verified when a Distributed Generation (DG) is placed in the system. In this paper, Generation Sensitivity Factors (GSF) has been computed for the understanding of a rescheduled generator, DG placed generation. The largest value of sensitivity factor represents the highest sensitive case by which the GM can be for the fixed load. IEEE-14 bus system is considered to show the effectiveness of the proposed method. Mi-Power software is used for the simulation purpose.*
Keywords: *generation rescheduling, generation sensitivity factor, distribution generation, generation management, energy management system.*

I. Introduction

Generation Management is one of the important aspects for the increasing demand in power sector under Energy Management System (EMS). This plays a vital role when the new/additional sources are added in the system. Without restructuring the complete system, the effect of adding a source may damage the existing transmission lines. To make the system retain without any effects of this scenario, there is a need to understand for the system security.

Real power generation rescheduling, Phase shifting transformers, Flow control through High Voltage DC (HVDC) link, Line switching, Load shedding has been given in [1, 2]. The optimal utilization of Flexible AC Transmission System (FACTS) for power flow management in the transmission lines are given in [3, 4, 5, 6]. Generation Rescheduling Technique (GRT) can be directly control the generation without curtailment of the load. So rescheduling generation is widely used [7, 8].

Distributed generation (DG) is also called as on-site generation, dispersed generation, embedded generation, decentralized generation, decentralized energy or distributed energy. Distributed generations (DGs) are small-scale power generation technologies of low voltage type and to produce electricity close to the end users of power [9, 10].

In the distributed power system, the energy management works on distribution of the power generated by the regenerative sources of energy as well as the demand of the load. With the management system developed not only the power generation of the shortest term dispatchable conventional plants, but also controllable or switchable the rescheduled loads [11].

The rest of the paper is organized as follows: Section 2 explains about the generation shift factors. Section 3 explains the proposed algorithm with generation rescheduling and incorporating DG in the system. Section 4 deals with the case study and results of the proposed algorithm. Finally, the conclusion is presented in section 5.

II. Generation Shift Factors

The easiest way to provide a quick calculation of possible scenarios like overloading of transmission lines is to use linear sensitivity factors. These factors show the approximate change in line flows for changes in generation on the network configuration.

The linear noniterative power flow algorithm can be given as

$$\begin{bmatrix} \Delta P_1 \\ \Delta P_2 \\ \vdots \end{bmatrix} = \left[B'\right] \begin{bmatrix} \Delta\theta_1 \\ \Delta\theta_2 \\ \vdots \end{bmatrix} \qquad (1)$$

(1) Can be written in a simplified manner as given below as in (2)

$$\theta = [x]p \quad (2)$$

The changes in bus phase angles $\Delta\theta$, for a given set of changes in the bus power injections Δp , can be given as in (3)

$$\Delta\theta = [x]\Delta p \quad (3)$$

The generation shift factors for a specified generator rescheduling is given by (4)

$$a_{li} = \frac{\Delta f_l}{\Delta p_i} \quad (4)$$

Where

l : Line index

i : Bus index

Δf_l : Change in megawatt flow on line l when a change in generation, Δp_i occurs at bus- i .

Δp_i : Change in generation at bus- i .

a_{li} : Sensitivity of the flow on line l to a change in Generation at bus i.

III. Proposed Algoritm

1. Read the load flow data.
2. Compute Ybus using the line data.
3. Carryout the base case load flow for computing the power flows at each line, voltages at each bus using Mi-Power software.
4. Reschedule the active power generation at each generator bus one at a time and obtain load flow results.
5. Compute the GSF using (4) for different generators rescheduled values.
6. Connect the distributed generators at the load bus which is physically far away from generating stations and obtain load flow results.
7. Compute the GSF using (4).
8. Compare the step 4 & step 6 results.

IV. Case Study And Results

In this section, numerical results are carried out on IEEE 14-bus system shown in Figure-4 to show the robust performance of the proposed algorithm.

Initially, the load flow solution using Newton - Raphson (NR) method without rescheduling was carried out & voltages at each bus and power flows at each line were obtained. Next, for the same system the load flow solution is obtained using NR method with rescheduling and installing distributed generation (DG) at load buses which is physically far away from generating stations i.e. 9 and 14.

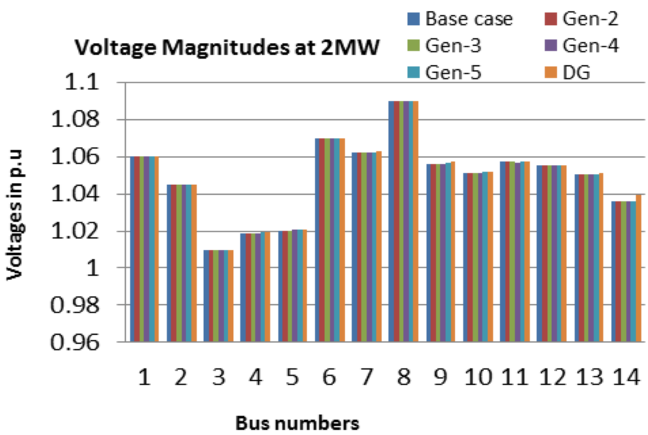

Figure-1: Voltage magnitudes for 2MW

When the generators-3, 4 & 5 are rescheduled by 2MW, the available voltage in buses 1, 2, 3, 6, 8,12 are constant, while in the remaining buses 4, 5, 7, 9, 10, 11, 13, 14 the voltage variation is very small are shown in Fig-1. But, when the generator-2 is rescheduled, there is no variation in all the buses. Similarly, when a DG is connected to the grid at load bus 9, there is some variation in all the buses except buses-1, 2, 3, 6 & 8.

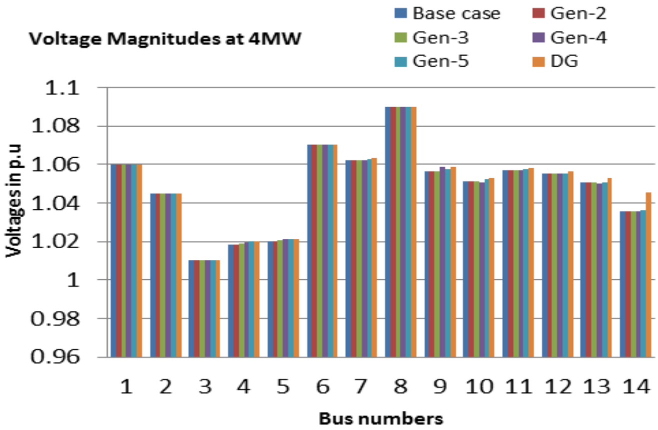

Figure-2: Voltage magnitudes for 4MW

When all generators-3, 4 & 5 are rescheduled by 4 MW, the available voltage in buses 1, 2, 3, 6, 8,12 is constant, while in the remaining buses 4, 5, 7, 9, 10, 11, 13, 14 the voltage variation is very small are shown in Fig-2. But, when the generator-2 is rescheduled, there is no variation in all the buses except bus-5. Similarly, when a DG is connected to the grid at load bus 9, there is slight variation in all the buses except buses-1, 2, 3, 6 & 8.

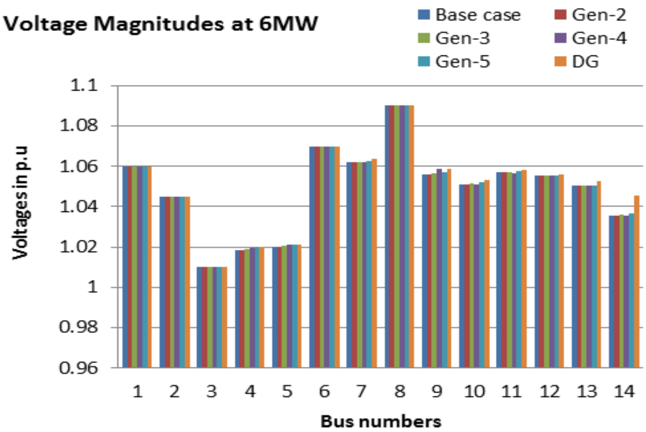

Figure-3: Voltage magnitudes for 6MW

When the generators-3, 4 & 5 are rescheduled by 6 MW, the available voltage in buses 1, 2, 3, 6, 8 is constant, while in the remaining buses 4, 5, 7, 9, 10, 11, 12, 13, 14 the voltage variation is very small are shown in Figure-3. But, when the generator-2 is rescheduled, there is no variation in all the buses except bus-5. Similarly, when a DG is connected to the grid at load bus 9, there is some variation in all the buses except buses-1, 2, 3 & 6.

Table 1. Generator Shift Factors For 2mw

Line	Generator -2	Generator -3	Generator -4	Generator -5	With DG
1-2	0.8825	1.7	1.388	1.473	
2-3	0.028	1.176	0.258	0.318	
2-4	0.059	0.292	0.514	0.624	
1-5	0.1625	0.552	0.78	0.729	
2-5	0.0795	0.138	0.54	0.45	
3-4	0.026	0.897	0.242	0.298	
4-5	0.0775	0.611	0.115	0.7	
7-8	0	0	0	0	
7-9	0.0035	0.026	0.392	0.737	
9-10	0.003	0.025	0.379	0.247	
6-11	0.0035	0.026	0.383	0.251	

6-12	0.0005	0.003	0.046	0.032	
6-13	0.002	0.014	0.195	0.13	
9-14	0.002	0.016	0.238	0.16	
10-11	0.003	0.025	0.378	0.247	
12-13	0	0.003	0.046	0.031	
13-14	0.002	0.016	0.238	0.159	

Out of all generators rescheduling by 2 MW, generator-3 has more affected the line in between bus-1 to bus-2 and the value of GSF is 1.7. So, this generator is more sensitive towards the line 1-2 is shown in Table-1. If the slack bus line is not considered as a sensitive line, the line in between bus-2 to bus-3 is more sensitive and the value of GSF is 1.176. Similarly, if DG is placed the more sensitive line is 1-2 and the GSF value is 0.7405. If the slack bus line is not considered as a sensitive line, the line in between bus-9 to bus-14 is more sensitive and the value of GSF is 0.606.

Table 2 . Generator Shift Factors For 4mw

Line	Generator -2	Generator -3	Generator -4	Generator -5	With DG
1-2	1.764	3.396	2.774	2.944	2.955
2-3	0.056	2.35	0.515	0.635	0.602
2-4	0.118	0.583	1.027	1.247	1.165
1-5	0.3355	1.124	1.579	1.477	1.572
2-5	0.159	0.276	1.079	0.899	1.026
3-4	0.0525	1.794	0.483	0.596	0.564
4-5	0.155	1.222	0.23	1.401	0.551
7-8	0	0	0	0	0
7-9	0.0065	0.052	0.784	1.474	1.42
9-10	0.006	0.05	0.756	0.495	0.195
6-11	0.0065	0.051	0.767	0.502	0.2
6-12	0.001	0.006	0.093	0.064	0.366
6-13	0.0035	0.027	0.391	0.041	1.333
9-14	0.004	0.032	0.476	0.319	2.421
10-11	0.006	0.05	0.755	0.493	0.194
12-13	0.0005	0.006	0.092	0.063	0.359
13-14	0.004	0.032	0.476	0.317	1.658

Out of all generators rescheduling by 4 MW, generator-3 has more affected the line in between bus-1 to bus-2 and the value of GSF is 3.96. So, this generator is more sensitive to wards the line 1-2 is shown in Table-2. If the slack bus line is not considered as a sensitive line, the line in between bus-2 to bus-3 is more sensitive and the value of GSF is 2.35. Similarly, if DG is placed the more sensitive line is 1-2 and the value of GSF is 2.995. If the slack bus line is not considered as a sensitive line, the line in between bus-9 to bus-14 is more sensitive and the value of GSF is 2.421.

Table 3. Generator Shift Factors For 6mw

Line	Generator -2	Generator -3	Generator -4	Generator -5	With DG
1-2	2.6445	5.089	4.156	4.412	4.421
2-3	0.084	3.523	0.772	0.952	0.9
2-4	0.177	0.874	1.539	1.87	1.743
1-5	0.508	1.694	2.377	2.225	2.363
2-5	0.2385	0.414	1.618	1.348	1.536
3-4	0.0785	2.691	0.724	0.893	0.844
4-5	0.2325	1.832	0.345	2.102	0.827
7-8	0	0	0	0	0
7-9	0.01	0.078	1.175	2.21	2.127
9-10	0.0095	0.075	1.134	0.742	0.292
6-11	0.0095	0.076	1.151	0.752	0.299
6-12	0.001	0.01	0.139	0.096	0.547
6-13	0.005	0.04	0.588	0.388	1.994
9-14	0.006	0.048	0.714	0.477	3.627
10-11	0.0095	0.075	1.132	0.74	0.29
12-13	0.001	0.009	0.138	0.095	0.537
13-14	0.006	0.048	0.714	0.475	2.482

Out of all generators rescheduling by 6 MW, generator-3 has more affected the line in between bus-1 to bus-2 and the value of GSF is 5.089. So, this generator is more sensitive to- wards the line 1-2 is shown in Table-3. If the slack bus line is not considered as a sensitive line, the lines in between bus-2 to bus-3 are more sensitive and the value of GSF is 3.523. . Similarly, if DG is placed the more sensitive line is 1-2 and the GSF value is 4.421. If the slack bus line is not considered as a sensitive line, the line in between bus-9 to bus-14 is more sensitive and the value of GSF is 3.627.

Table 4. Active power losses at all the rescheduling generations

Rescheduled Power (MW)	Generator -2	Generator -3	Generator -4	Generator -5	With DG
2	13.278	13.116	13.200	13.166	13.109
4	13.170	12.848	13.015	12.947	12.841
6	13.063	12.585	12.835	12.732	12.584

The active power loss with generation rescheduling and incorporating DG in the system is given in Table-4. Out of all the generation rescheduling, generator-3 gives less power losses as the load is connected near to the bus-3. Similarly, the incorporation of DG also reduces the losses in the system, when compared to the active power loss in the base case is 13.3874.

V. Conclusion

The effect of rescheduling an existing generator and a DG placed generation enhancement has been presented. Sensitivity analysis has been carried out for understanding the most sensitive line. Under generator rescheduling most of the transmission lines were not affected which are far from the generator buses. Thus, the generation management can be performed based on the GSF with respect to the transmission lines connected to the associated bus. In this process the real power flow sensitivity index and the bus voltages have improved.

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