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Research Article

Based on Load Maximum Capacity of Distributed Generation unit in Radial Power System

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Abstract

Due to technology improvement, energy market liberalization and environmental issues it has been witnessed an increasing allocation of distributed generation (DG) in the distribution networks. Every year, Distribution Network Operators (DNOs) receive several requests for installations of new generators in the existing networks. This situation is likely to imply a revolution in the distribution networks. The basic aim behind this is to maintain a sufficient level of system stability and instantaneous operation of power system by including the participation of energy and service. In this paper it has been analyzed how DSM policies can be a valid opportunity to facilitate the development of DG in a given distribution system and which economical benefits the utilities can derive by the complementary employ of both these distributed resources. Simulation studies have been performed on a real distribution networks, showing the effect of DSM action on the growth of DG in the distribution system and on the technical and economic benefits, they permit to realize.

Keywords: *Radial Network, Distributed Generation unit, Maximum cost, Penalty Factor, Energy Saving, Environmental issues, Demand Side Management.*

1. Introduction

1.1 Distributed Generation (DG)

Distributed generation is any electricity generating technology installed by a customer or independent electricity producer that is connected at the distribution system level of the electric grid. This includes all generation installed at sites owned and operated by utility customers, such as photovoltaic systems serving a house or a cogeneration facility serving an office (Hoff.T., 2007). The definition given does purposely lack information concerning

- Power rating and technology
- Environmental impacts
- Delivery area
- Mode of operation

This allow a more general discussion of various aspects, since many issues regarding the interaction between DG and the existing grid- as e.g. deep and shallow connection charges or protection aspects - are similar for the different types of DG.

The main benefit of installing a distributed generation system is the assurance of receiving power from the utility when your system is not running. This is essential for many renewable technologies like solar and wind, which produce intermittent power and for other technologies that may need to be shut down for periodic maintenance.

1.2 Demand Side Management (DSM)

Demand Side Management (DSM) is another option which is equally important and beneficial as that of distributed generation in improving the energy scenario. It is observed that, by inclusion of new energy sources we are only supplying the increasing demand, while an inherent deficit prevails. Therefore, on the demand side, more efficient ways of utilization of the available energy has to be employed. The purpose of demand side management is energy conservation and the salient features of energy conservation are (Garcial A. A., 1987).

- Setting up of energy conservation standards for any equipment or appliance consuming, generation, transmitting or supplying energy.
- Mandatory energy audit for all designated consumers, as and when required by the designated authority.
- Promotion of mass awareness at both the Central and the State levels for energy conservation, consumer education and guidance
- Constitution of an Energy Conservation Funds at the Centre and the State for utilizing any grant or loans made available for promoting energy conservation.

This paper present a method to estimate how much a

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utility can afford to pay for these alternatives when the change in system capacity due to the distributed resource is constant from year to year and when there is no uncertainty.

2. Problem Formulation

In radial connected network the concept of demand side management (DSM) and DG are integrated. The voltage rise caused by DG is a well-known effect and can be illustrated using the simple circuit shown in Fig.1. This figure represents the basic features of a distribution system into which a distributed generator, G, is connected at the MVA level. During formulation the major role are played by compensation devices. During light load conditions it takes reactive power from the load bus and when loads at the load centre increases than compensation devices are operated again and dissipates reactive power to the load buses. In this paper active networks are considered.

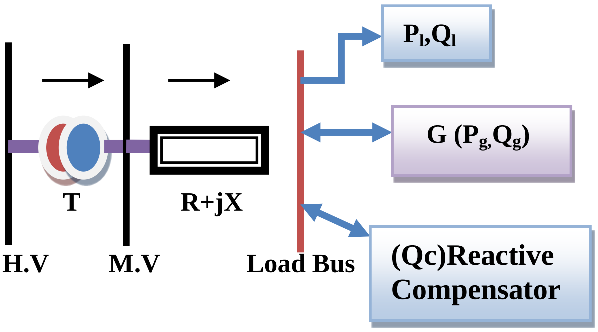

Figure 1 Radial Connected Power System

During problem formulation a similar approach is followed but, in order to make a comparison, the effect of a DSM action able reduce the peak load by increasing the energy demand during the low load condition has been investigated. . In this particular case, some loads can be controlled by DSO and agree to be connected when necessary (e.g. loads with storage features) or some other loads are moved to change their normal behavior and convinced to use more energy during off peak hours.

2.1. Relation between maximum generation and load connected

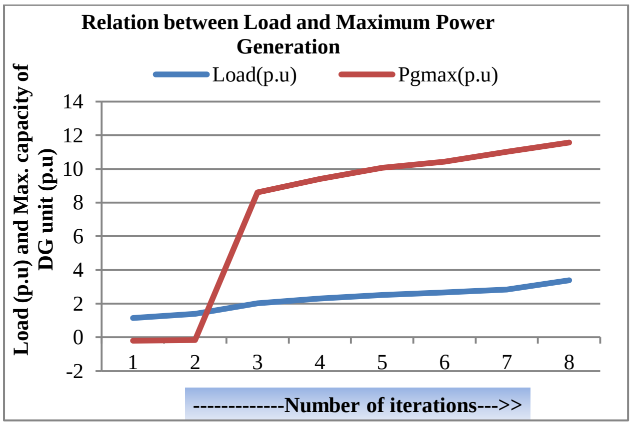

Figure 2 Relation between load and Maximum Power Generation

The graphical representation of evaluated results is shown in fig 2. The variation of maximum capacity of distributed generation unit (P_{gmax}) in per unit, variation of load (P_l,Q_l) in per unit on vertical axis w.r.t. number of iterations on horizontal axis. It is seen that as the demand of load on consumer side increases the maximum capacity of DG unit installed at load bus increased. The aim of demand side management (DSM) in this type of situations is to encourage customers to use minimum load. Otherwise the role of distributed generation company increases that effect per unit consumption cost.

2.2 Present work

The work that is done here is based on Radial connected network shown in Fig. 1.

If load (P_l,Q_l) connected with the load bus is less corresponding to power available than DG unit is shut down, but if load on consumer side increases beyond the limits of power available in the load bus than DG unit is operated. The maximum power generated by DG unit corresponding to load connected with the load bus is carried out by using this equation (G. Celli, E. Ghiani, S. Mocci, F. Pilo, E. Pazzola, 2005) .

$$P_{gmax} \leq (V_{2max} - V_1)/R \quad (1)$$

Where
V_{2max}= maximum voltage present at load bus
V_1= voltage at bus 1
R= resistance of tie line between bus 1 and bus 2.

The voltage V_{2max} is further calculated by using this equation:

$$V_{2max} = V_1 + R \times (P_g - P_l \pm P_{dsm}) \pm X[(\pm Q_g - Q_l \pm Q_c)] \quad (2)$$

P_{dsm} is the portion of total load that can be moved from peak hours to off peak hours.
X= reactance of tie line between bus 1 and bus 2.
P_g and Q_g is active and reactive power of DG unit.
P_l and Q_l is active and reactive load connected with load bus.
Q_c is reactive power of compensating device.

When load on consumer side is maximum/Normal than The maximum output of distributed generation unit (P_{gmax}) is calculated by using this equation.

$$P_{gmax} \leq (V_{2max} - V_1)/R + \Delta P_{dsm}/R \quad (3)$$

The voltage on load bus is calculated by using (2) equation. Equation (3) shows a linear relationship between the portion of loads involved in DSM program and the increasing of maximum allowable level of DG unit. In other words, DG owner accept to pay a fee for the active network service (in this case the active network service is constituted by the action on loads) but they can have a major income by selling more energy during the peak hours.

The maximum cost received by DG unit or paid by DG unit is calculated by using following relation.

$$C[P_g]= \lambda[a\times(P_{gmax})^2+b\times P_{gmax}] \quad (4)$$

Where a and b are constants.

The above written equation is a typical cost characteristics equation to calculate the cost of DG unit during operation. Here λ is penalty factor that decides the rate at which power is taken or given by DG unit.

3. Maximum power generated by DG unit during operation

In this analysis, it is considered that the demand of consumers is continuously increases. The active and reactive load powers at load centers decide the operation of distributed generation unit. From below written table it is cleared that the concept of DSM involve in the network during peak load conditions. Greater is the load; greater is the capacity of DG unit and vice versa.

The Following table shows result related to above discussion. Here analysis is done by taking 8 iterations using simulation tool. The output power (P_{gmax}) is converted from p.u. to MW by taking 100 MVA base.

Table 1 Maximum power generated by DG unit based on load connected

Iteration	P_l(p.u)	Q_l(p.u)	P_{gmax}(p.u)	P_{gmax}(MW)
1	0.8	0.34	-0.2	-20
2	1	0.4	-0.16	-16
3	1.4	0.62	8.61	861
4	1.58	0.72	9.4	940
5	1.72	0.8	10.07	1007
6	1.8	0.86	10.43	1043
7	1.94	0.9	11.02	1102
8	2.4	0.98	11.57	1157

Take- Z (p.u) =0.05+j0.15, V_1=2.0 p.u, Base = 100 MVA

From the initial 2 iterations negative sign indicates that the power available at load bus is sufficient to fulfill the requirements of consumers. Under such cases, if DG unit is installed than it draws power from the load bus.

3.1 Cost of DG unit during operation with fixed penalty factor

In this analysis, the cost of distributed generation (DG) unit during operation is calculated. At normal load, it absorbs power from the load bus and at peak loads it gives power to the load bus. The rate under this operation is decided by two companies (one is main company and other company consists DG unit). In this sub part of result analysis, the penalty factor is considered to be same during peak and off peak loads. The results corresponding to this discussion is written below. The penalty factor λ=1.0 and is fixed for all stages of load.

Table 2 - Maximum capacity of DG unit installed with fixed penalty factor

Iteration	P_{gmax}(MW)	P_{cost}(Rs/MW)
1	-20	-299
2	-16	-239
3	861	13004
4	940	14188
5	1007	15206
6	1043	15768
7	1102	16651
8	1157	17504

Conclusions

It is to be observed that with the increase in load the capacity of DG unit and the maximum generation of DG unit increases and vice versa. The capacity further depends upon the price set by two companies at different instants of load. The deal sign by two companies play a great role when DG unit is in operating condition. The basic aim behind this is energy conservation. The tariff given by customers during peak and off peak loads is depending on the penalty factor. This concept is further integrated with DSM.

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