OPTIMAL INTEGRATION OF DISTRIBUTION SYSTEM OF DG UNITS BASED ON WIND GENERATOR WITH CONSIDERATION OF UNCERTAINTIES

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Abstract: *Global environmental problems associated with traditional energy generation have led to a rapid increase in the use of renewable energy sources (RES) in power systems. The integration of renewable energy technologies is commercially available nowadays, and the most common of such RES technology is wind turbine (WT). This paper proposes an application of Salp Swarm Algorithm (SSA) for determining the optimal allocation of WT based distributed generation (DG) units in the distribution system (DS) with the aim of minimizing the total power and energy losses.*

Keywords—uncertainties; wind turbine; differential evolution algorithm; distribution system

1.INTRODUCTION

In the last few years, considerable attention has been paid to the usage of RES (such as WT, etc.) to minimize power losses due to global environmental problems associated with traditional generation. Many countries have been introduced or are proceeding towards the implementation of renewable energy policies like the Renewable Energy Portfolio Standard (RPS) [1]. Accepting an RPS is a production obligation of a certain percentage of the total electricity production from RES for a specific date. However, available WT energy is unstable and variable.

WT produces energy when exposed to wind speed, and several other components are needed to properly conduct, control, convert, distribute and store the energy produced by the turbine. In restructured power systems, the use of distributed generation energy resources, including wind turbine (WT), fuel cells, small micro turbines, etc. The advantage of distributed generation energy resources includes reducing power and energy losses, improving voltage profile (VP), and increasing network reliability. To achieve the advantages of DG units, the choice of the optimal location and size becomes a major problem [2].

2.Problem formulation

Objective function

The objective of this article is to minimization the real power and energy losses and improve the DS voltage.

Real power loss

The first term of the objective function is the real power loss, which is determined by equation (1)

$$P_{LOSS}=\sum_{j=1}^{n_f}\sum_{k=1}^{n_s} R_k \vee I_k^2 \vee ¿ \quad (1)$$

Accordingly, minimizing the total active power losses in the DS leads to reduce the total active energy losses E_{loss} during 24 hrs as:

$$E_{loss}=\sum_{t=1}^{24} P_{loss}(t)\Delta t \quad (2)$$

where,

$I_k - ¿$ Is the current passing through line k

$n_f - ¿$ Is the total number of branches

$n_s - ¿$ Total number of sections in the system

$R_k -$ Resistance of the line section between buses *k* and *k* + 1

Voltage Profile improvement

The second goal of this work is to improve the VP, which is represented by the VP index in equation (3) [8].

$$VP=\sum_{j=1}^{n_f}\sum_{k\in lb}|V_k-V_{ref,k}| \tag{3}$$

where,

$lb -$ Collection of the load buses

$V_{ref,k} -$ Nominal voltage at load bus *k*.

$V_k -$ Voltage amplitude at bus *k*.

3.WT AND LOAD MODELS

3.1.1 Wind speed modeling: Weibull PDF was chosen to evaluate the stochastic behavior of wind speed at a predetermined duration of time. Weibull PDF for wind speed v_t (m/s) at the t-th time interval can be calculated as:

$$f_t(v^t)=\frac{k^t}{c^t}*\left(\frac{v^t}{c^t}\right)^{k^t-1}*\exp\left(-\left(\frac{v^t}{c^t}\right)^{k^t-1}\right) \quad for \quad c^t>1;\ k^t>0 \tag{4}$$

The shaping rate (k^t) and scale rate (c^t) at tth time interval are expressed as [9]:

$$k^t=\left(\frac{\sigma^t}{\mu_v^t}\right)^{-1.086} \tag{5.1}$$

$$c^t=\frac{\mu_v^t}{\Gamma(1+1/k^t)} \tag{5.2}$$

where, μ_v^t and σ^t are mean and Sd of wind speed at time interval ‘t’.

3.1.2 WT power generation: The hourly WT average output power corresponds to a specific time interval ‘t’ (P^t_{WT}) can be expressed as (6). A typical day for three years is generated in p.u., as shown in Fig. 4.

$$P_{WT}^{t} = \sum_{g=1}^{n_s} P_{WT_g}(v_g^t) f_b(v_g^t) \tag{6}$$

where ‘g’ denotes a stage factor and n_s is the number of wind speed discrete stage. v^t_g is the g^{th} stage of wind speed at t^{th} time interval.

The WT power generation [9] with an average wind speed (v_{ag}) for stage “g” is expressed as:

$$P_{WT_g} = \begin{cases} 0 & v_{ag} < v_{cin} \quad or \quad v_{ag} > v_{cout} \\ (A * v_{ag}^3 + B * P_r) & v_{cin} \le v_{ag} \le v_r \\ P_r & v_r \le v_{ag} \le v_{cout} \end{cases} \tag{7}$$

where P_r is the nominal power rate that WT can be generated; v_{cout} is cut-out; cut-in (v_{cin}) and nominal (v_r) wind speed, respectively, constants A and B are achieved]:

$$A = \frac{P_r}{(v_r^3 - v_{cin}^3)} \tag{8.1}$$

$$B = \frac{v_{cin}^3}{(v_r^3 - v_{cin}^3)} \tag{8.2}$$

3.2Load model

The load demand for the system is modelled corresponding to the normalized daily 24- hours load curve with a peak of 1 pu, as shown in Fig. 1 [10-11]. The load factor (LF) can determine as the field beneath the load curve, the load curve in p.u. subdivide by the sum of time interval [3]

$$LF = \sum_{t=1}^{24} \frac{per\ unit.\quad Demand(t)}{24} \tag{9}$$

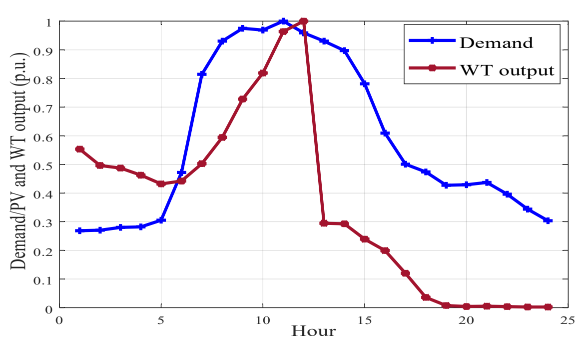

Fig 1. Normalized daily active load curve and WT output

The voltage-dependent load demand model, which includes variable load over time, can be calculated as [4]:

4.CONCLUSION

The proposed approach is used to reduce power losses, energy loss and improve VP in the distribution system. To test the effectiveness of the proposed approach was tested on a test system with a standard 33 bus system. For the 69-bus system, the loss reduction is 98% and energy loss reduction is 66 %. In addition, the VP performance is improved over the base system.

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