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ANALYSIS OF DG SYSTEMS WITH WIND FARMS IN IRAN AZARBAIJAN

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Abstract- In this paper research results of characteristics of wind energy potential at some of Azarbaijan areas of Iran are presented. Estimation of wind energy potential, which is done for the first time, has confirmed the efficiency to use wind units in Azarbaijan areas. Expected annual capacity of wind energy unit is determined on the base of two parameters Weybull model for wind speed distribution function and for using DG systems.

Keywords: Wind Energy, Wind Speed, Azarbaijan Wind Potential, DG System.

I. INTRODUCTION

Application of Azarbaijan (Iran) wind turbines in Distributed Generation (DG) systems is very favorable because Azarbaijan area usually has big wind potential. Study of wind potential in Azarbaijan area is very important and the attention to this subject is rising because the electrical energy consuming is much amount in the area. DG generally refers to small scale (typically 1 kW - 50 MW) electric power generators that produce electricity at a site close to customers or that are tied to an electric distribution system. Distributed generators include, but are not limited to synchronous generators, induction generators, reciprocating engines, microturbines (combustion turbines that run on high-energy fossil fuels such as oil, propane, natural gas, gasoline or diesel), combustion gas turbines, fuel cells, solar photovoltaics, and wind turbines.

There are many reasons that a customer may choose to install a distributed generator. DG can be used to generate a customer's entire electricity supply; for peak shaving (generating a portion of a customer's electricity onsite to reduce the amount of electricity purchased during peak price periods); for standby or emergency generation (as a backup to Wires Owner's power supply); as a green power source (using renewable technology); or for increased reliability. In some remote locations, DG can be less costly as it eliminates the need for expensive construction of distribution and/or transmission lines.

The distributed generation systems include the following benefits.

- a lower capital cost because of the small size of the DG (although the investment cost per kVA of a DG can be much higher than a large power plant).
- reduce the need for large infrastructure construction or upgrades because the DG can be constructed at the load location.
- if the DG provides power for local application, it may reduces the pressure on distribution and transmission lines.
- with some technologies, produces zero or near-zero pollutant emissions over its useful life (not taking into consideration pollutant emissions over the entire product lifecycle i.e. pollution is produced during the manufacturing, or after decommissioning of the DG system).
- with some combined technologies such as solar or wind as a form of renewable energy the power reliability is increased as back-up or stand-by power to customers.
- offers customers a choice in meeting their energy needs.

II. DYNAMIC MODEL OF WIND POWER UNIT

The developments of wind energy systems and advances in power electronics have enabled an efficient future for wind energy. Our simulation study compares three control schemes used in wind energy systems. Three widely used control schemes for wind energy systems are Pitch control, Rotor resistance control and Vector control of double fed induction generators and their effectiveness in controlling the fluctuations in the output power occurring due to wind speed variations.

The mathematical models built in SIMULINK to simulate the systems are described here. The control system design for the power control mathematical model is discussed and the chapter concludes with an analysis of the simulation results comparing the three control techniques.

A traditional wind energy system consists of a stall-regulated or pitch control turbine connected to a synchronous generator through gearbox. The synchronous generator operates at fixed speed and one of earliest rotor control schemes was the rotor resistance control. The speed of an induction machine is controlled by the external resistance in the rotor circuit.

The drawback of the above two methods is the inability of wind power to capture at low wind speeds. The double fed induction machine is an extension of the slip power recovery scheme, wherein the machine can be made to act like a generator at both sub synchronous and super synchronous speeds. Power factor control at the grid side can be obtained by controlling the grid side converter. The three methods used in wind energy systems, the output variations for the different control techniques for a change in the input wind velocity and a constant desired output power reference are compared and the methods are evaluated based on the response time and the magnitude of change in the output power compared to the desired output power and also compared by simulation in SIMULINK.

III. TYPICAL WIND TURBINE GENERATOR

The basic components involved in the representation of a typical wind turbine generator are shown in Figure 1.

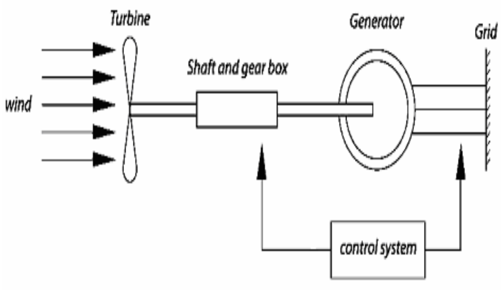

Figure 1. Components of a typical wind system

The converter and the rectifier on the rotor side are replaced by bidirectional converters. An entire wind energy system can be sub divided into following Components:

1. Model of the wind,
2. Turbine model,
3. Shaft and gearbox model,
4. Generator model and
5. Control system model.

The first three components form the mechanical part of the wind turbine generator. The generator forms the electro-mechanical link between the turbine and the power system and the control system controls the output of the generator. The control system model includes the actuator dynamics involved, be it the hydraulics controlling the pitch of the blades, or the converters controlling the induction generator.

IV. MODEL OF THE WIND

The model of the wind should be able to simulate the temporal variations of the wind velocity, which consists of gusts and rapid wind speed changes. The wind velocity (V_W) can be written as:

$$V_W = V_{WB} + V_{WG} + V_{WR} \quad (1)$$

where,

V_W: Tital wind velocity,

V_{WB}: Base wind velocity,

V_{WG}: Gust wind component and

V_{WR}: Ramp wind component.

The base wind speed is a constant and is given by:

$V_{WB} = C_1$; C_1 = constant

The gust component is represented as a (1-cosine) term and is given by:

$$V_{WG} = \begin{Bmatrix} 0 & t < T_1 \\ C_2 \left\{ 1 - \mathrm{COS}\left[\pi \dfrac{t - T_1}{T_2 - T_1} \right] \right\} & T_1 \le t \\ 0 & t \ge T_2 \end{Bmatrix} \quad (2)$$

where C_2 is the maximum value of the gust component and T_1 and T_2 are the start and stop times of the gust, respectively. The rapid wind speed changes are represented by a ramp function, which is given by:

$$V_{WR} = \begin{Bmatrix} 0 & t < T_3 \\ C_3 \left[\dfrac{t - T_3}{T_4 - T_3} \right] & T_3 \le t \le T_4 \\ 0 & t \ge T_4 \end{Bmatrix} \quad (3)$$

where C_3 is the maximum change in wind speed caused by the ramp, and T_3 and T_4 are the start and stop times of the ramp, respectively.

The noise component of the wind speed is not modeled, as the large turbine inertia does not respond to these high frequency wind speed variations. The wind speed profile used to compare the three power control methods is shown in Figure 2. The S-function use the model of the wind velocity in SIMULINK.

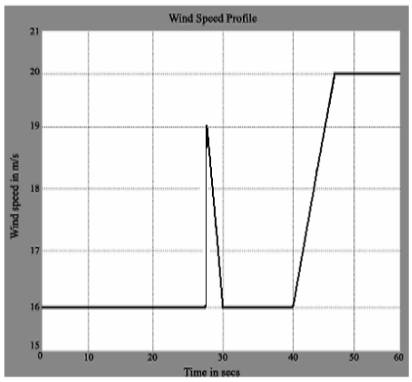

Figure 2. Wind speed profile used for simulation

V. MODELING OF STUDY

In this paper, research results of wind parameters as energy source are presented for Azarbaijan areas in Iran. This data makes it possible to decide which wind energy unit is feasible to install in the selected area. For assessment of Azarbaijan wind turbines operation efficiency by application of probabilistic-statistical methods for each area, it is required to determine annual average wind speed, probability function distribution and expected amounts of annual generated power.

There are some evaluation methods of expected electrical energy produced by wind generator electrical energy produced by wind generator. Determination of annual production of electrical energy by wind generator unit is based on the estimation of root-mean-cube wind speed. It assumes that the power factor defines the grade of wind potential and is not dependent of wind speed. Therefore, this method is good enough to determine power density and then used to estimate wind potential of the region.

Another method is based on linear dependence of output power of wind turbine from the speed. The speed magnitude is established from the probabilistic function of its reiteration. The method is assuming that operation of wind turbine would take place on the linear part of wind turbine power which depends on wind speed function. So, essential part of wind power generation would take place on mentioned linear segment of power-speed characteristic. The third method of determination the total energy production is more accurate and is based on utilization of wind speed distribution function.

Because of difficulties in construction of such function for all spectrums of regions, where wind turbines would be located, the approximated wind speed distribution function is used. There are also some other methods, which consider that power of wind generator is presented as a function of wind energy potential and unit's feature. Though such approach is more universal and free of some other methods disadvantages, nevertheless it also assumes that power factor of wind turbine is not dependent from the wind speed.

In this paper modeling of wind generator power is considered as a function from probabilistic characteristics of wind potential and unit feature, probabilistic functional dependences of wind speed and parameters of wind in offshore areas of Azarbaijan (Iran). Amount of energy produced by installed wind energy units is defined and we can use for DG systems.

The calculation of electrical production by wind power station is done for Azarbaijan area in Iran. Study of the wind potential includes time-continuous measurements of wind speed in Azarbaijan where gas production facilities are also performed. At the moment the embedded diesel-generator power units supply these facilities. In future the combination of wind energy and diesel energy system would improve efficiency of energy supply for petrol and gas producing units in Azarbaijan.

Probabilistic-statistical wind speed variability characteristics are determined for measurement data received at the period from February 2004 till February 2009. Figures 3 and 4 present wind speed variations obtained with half an hour averaging further time period in Feb. 2009. To evaluate wind generators power and produced electrical energy in accordance with expressions in Table 1 it is necessary to find parameters a and b of probability density function (2) which represents wind energy utilization factor. For this purpose, experimental estimation of average values and wind speed probability density distribution were determined for examined areas (Figures 5 and 6).

Weybull function smoothing is applied to experimental diagrams of probability density function. As a result of smoothing estimation of parameters for two-dimensional, the vector $param = [a, b]$ for the under consideration areas would be:

Region 1: a=10.4; b=2.6 Region 2: a=10.8; b=2.9

Smoothed according Weybull expression probability density function of wind speed repetition is presented in Figures 7 and 8. To calculate the produced electrical energy it is also necessary to have data about wind speed distribution. To take in account dependence of wind speed, the expression is determined by approximation of experimental data.

The main technical data for Vestas V80-2.0 MW is in table devaluation of annual produced electrical energy. The mentioned models are used to wind energy potential and technical features to calculate produced power and expected energy of each area. As a result of calculation the generate power is 640 kW. It is seen that the evaluated production of electrical energy for both examination exceeds the value stated by wind turbine producing company (4150250 kWh).

Table 1. Specification of sample turbine

V [m/s]	*P* [kW]	*Cp*
3	0.88	0.09
2.8	38.5	0.261
4	59.2	0.275
4.13	95.23	0.312
4.6	146.2	0.35
5.12	215.2	0.4
5.8	275.3	0.4
6.41	370.2	0.401
6.21	462.2	0.402
7.20	592.2	0.403
7.2	736.2	0.42
8.1	842.2	0.463
8.2	1013.22	0.362
9.11	1122.2	0.402
9.2	1344.00	0.42
10.0	1422.23	0.355
9.55	1566.1	0.371
9.5	1656.00	0.342
12.0	1850.00	0.265
12.11	1826.00	0.300
12.55	1920.00	0.244
12.22	1962.00	0.211
13.22	1955.00	0.211
13.55	1952.00	0.111

VI. CONCLUSIONS

1. The Azarbaijan wind potential on the base of wind speed probabilistic-statistical functions is estimated.
2. The annul amount of energy produced by wind power station the suggested model is evaluated to considering dependence of density distribution function from wind speed and units feature. The suggested method takes in account power factor variability of wind speed (Figure 9).
3. The values of annual energy production are calculated to confirm high efficiency of using wind potential in Azarbaijan (Iran).
4. Results show that adjusting wind system of DG system in the Azarbaijan, it is required for attention of wind farms and wind Atlas.

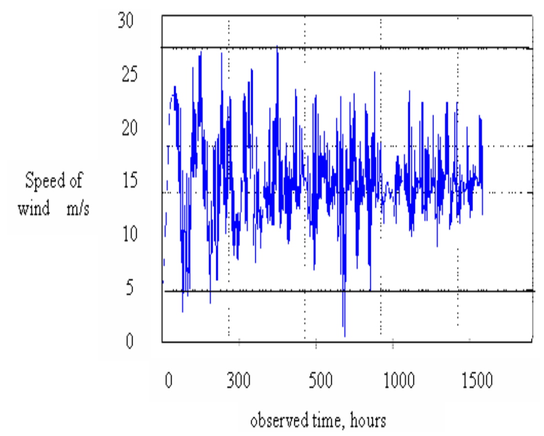

Figure 3. Wind Speed Variation (Feb-Aug 2004) in the step (1)

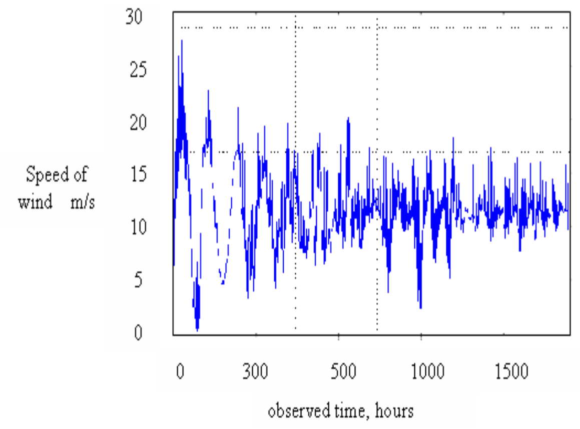

Figure 4. Wind Speed Variation (Feb-Aug 2009) in the step (2)

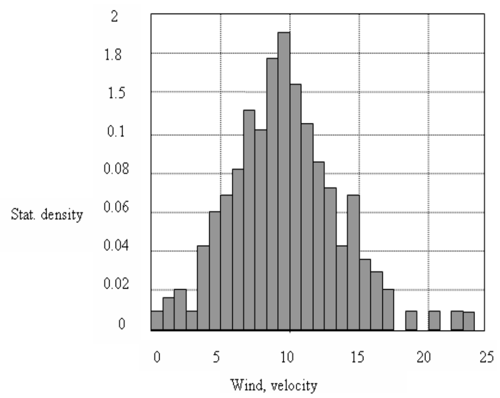

Figure 5. Wind speed probability density in the step (1)

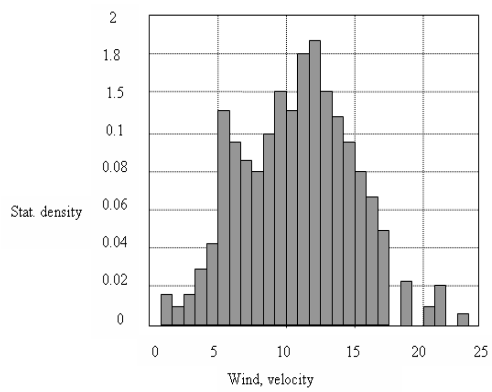

Figure 6. Wind speed probability density in the step (2)

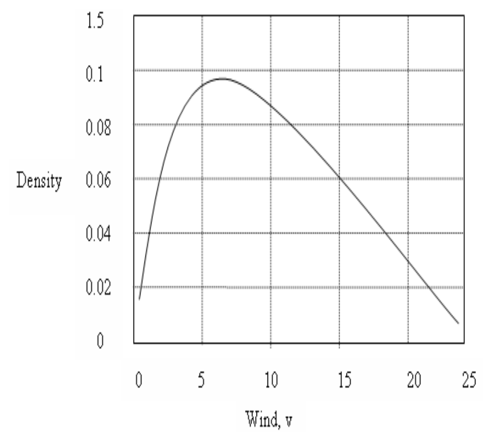

Figure 7. Weybull probability speed probability density in function for wind speed in the step (1)

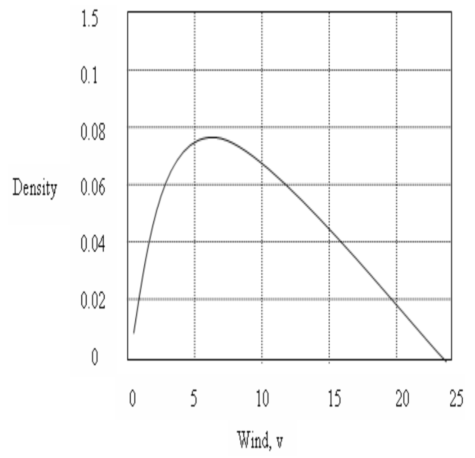

Figure 8. Weybull probability speed probability density in function for wind speed in the step (2)

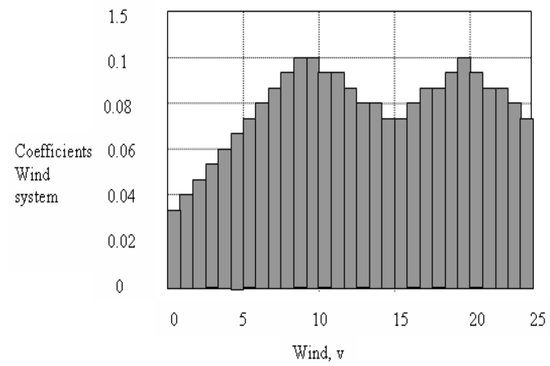

Figure 9. Power factor of wind unit

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BIOGRAPHIES

Farrokh Fattahi was born in Tabriz, Iran. He received his B.Sc. in Electrical Engineering and M.Sc. degree From Amir-Kabir University in 1998 were he is currently working toward the Ph.D. in electrical engineering in Azerbaijan National Academy of Sciences (Baku, Azerbaijan). He got valuable Results about Application of Laser in Electrical and Electro-medical Engineering. by license of Cleveland University of USA. Recently he study on Management of DG Systems on Elec. Networks.

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Naser Mahdavi Tabatabaei was born in Tehran, Iran, 1967. He received the B.Sc. and the M.Sc. degrees from University of Tabriz (Tabriz, Iran) and the Ph.D. degree from Iran University of Science and Technology (Tehran, Iran), all in Power Electrical Engineering, in 1989, 1992, and 1997, respectively. Currently, he is a Professor of Power Electrical Engineering at International Ecoenergy Academy, International Science and Education Center and International Organization on TPE (IOTPE).
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He is the secretary of International Conference on TPE (ICTPE) and editor-in-chief of International Journal on TPE (IJTPE). His research interests are in the area of Power Quality, Energy Management Systems, ICT in Power Engineering and Virtual E-learning Educational Systems. He is a member of the Iranian Association of Electrical and Electronic Engineers (IAEEE).