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Design of a wind turbine model for clean energy. Case study: Khorasan Razavi regional electricity company

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Abstract. Using wind as a clean and free source of generating electrical energy has been increasingly developed so that wind generated electricity by 2015 equals 5.5 % of total electrical energy produced in the world, and by 2020, 10 % of the total global electricity would be obtain from wind. Thus, the purpose of the present research is to study effective organizational strategies on investment for wind energy utilization in Khorasan Razavi Regional Electricity Company. This is an applied study in term of purpose and a descriptive survey in term of data collection and processing. Research statistical population included 200 managers, employees, consultants, and experts affiliated to strategic planning at Khorasan Razavi Regional Electrical Company headquarter in 2016. 127 samples were randomly selected through simple random sampling method. Research data were collected through using a questionnaire the reliability of which was measured 0.796 through using Chronbach's alpha test. Research results indicate that the organizational strategy influences investment on utilizing wind energy in Khorasan Razavi regional electricity company. Further, of 9 identified strategies, environmental assessment strategy in strategic planning process and change management in strategic planning process showed no significant effect on planning wind energy utilization in Khorasan Razavi regional electricity company.

Key words. Wind turbine, organizational strategy, investment in wind energy, regional electricity, Khorasan Razavi.

1. Introduction

Power plays a critical role in formulating economic development plans including economic development, welfare and improved life conditions, increased income, and national economic growth factors, which are largely influenced by power effects. Nowadays, wind is used for several functions. Wind turbines construction focuses on windmills, water pumping wind turbine, agricultural wells power supply, fish

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farming, improving the environment, as well as electricity generation for industrial and household. National development infrastructures and economic development rely upon infrastructure projects. In developing countries, infrastructures are mostly delayed due to huge capitalization; and hence, are the first items removed at the time of debt and budget deficiency comparing public current costs. In 2015, about 50 GW of wind energy potential has been operated, which raised global wind energy potential up to 30 % to 480 GW. This level of increased power capacity was larger than other renewable technologies in the year. During 2015, 80 nations have added their capacity and at least 85 nations have reported an increase by more than 10 MW; 22 nations of which have passed 1 GW and 87 % of total global capacity has been attributed to the top 10 nations. Leading countries in the area of new installations included China, U. S. A, India, Germany, and U. K followed by Canada. The UE has 23 % of the global market and 41 % of global total capacity [1, 2].

To use extant wind sources for power generation in Iran, it requires reliable information of wind potential in understudied region for wind power plant construction. Iran, regarding windy areas, provides a proper foundation for developed utilization of wind turbines. According to wind Atlas and based on the data of 60 stations at different national regions, the sites' nominal capacity is about 60 000 MW. Relying upon the predictions, the amount of national economic recoverable wind energy is estimated up to 18 000 MW demonstrating considerable national potential in the area of wind power plant construction, and cost-effective investment in wind energy industry. Lahmeyer Group has cooperated in running wind potentiometric project in Iran and estimated recoverable wind potential about 100 000 MW.

Regarding advantages of wind power plant construction, it is necessary to mention that launching the power plants may obviate wind turbine demands; moreover, it also replies some part of national and international power supply demand and is easily converted to electrical energy. Variation in energy sources, sustained energy system, high maneuver in utilization from a watts to several MW, no need for water, and no environmental pollution, high efficiency, as well as wind energy in most central, desert, and mountainous areas are other advantages of power plants [3, 4].

2. Proposed method

The dynamic analysis of conventional electrical machines is performed using dynamic analytical equation for each phase winding. The basic scheme is depicted in Fig. 1.

The terminal voltage of the TFG can be determined differentiating the flux linkage of the stator windings, as shown in equation (1). This equation is a general form of stator voltage for alternating current generators [5]. The flux linkage is computed as function of rotor position and armature currents by 3D static finite element analysis [5]. The form of equation (1) must be expanded to implement the look-up table data. Finally, the current differential term of the equation is isolated and implemented in Matlab/Simulink.

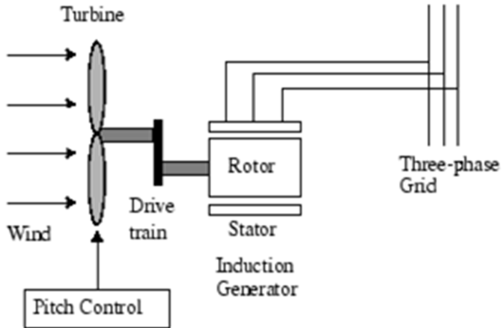

Fig. 1. Wind turbine modeling

$$v(t) = -Ri(t) + \frac{\mathrm{d}\lambda(i,\theta)}{\mathrm{d}t}\,, \tag{1}$$

$$\frac{\mathrm{d}i}{\mathrm{d}t} = \left(v(t) + Ri(t) - \frac{\mathrm{d}\lambda(i,\theta)}{\mathrm{d}\theta}\omega_{\mathrm{m}}\right)\frac{\mathrm{d}i}{\mathrm{d}\lambda(i,\theta)}\,. \tag{2}$$

Here, $v(t)$ is the terminal voltage, R is the phase resistance, $i(t)$ is the phase current, t is time, θ is the rotor angular position of the electric system and ω_m is the angular velocity of the rotor.

The aerodynamic torque developed by the rotor blades is calculated in this subsystem using the theory given in [4]. The kinetic energy E [J] of air mass m [kg] moving at a speed v_{wind} [m/s] is

$$E = \frac{1}{2}mv_{\mathrm{wind}}^2\,. \tag{3}$$

If the air density is ρ [kg/m^3], mass flow through an area A is given as

$$\dot{m} = \rho A v_{\mathrm{wind}}\,. \tag{4}$$

Thus, the equation for the power (in W) through a cross-sectional area A normal to the direction of wind is

$$P_{\mathrm{wind}} = \frac{1}{2}\rho A v_{\mathrm{wind}}^3\,. \tag{5}$$

In the case of a wind turbine, the area A is the area swept by the rotor blades. Only a part of this power may be captured due to the non-ideal nature of the rotor, hence the need for the coefficient C_{p}. The result is shown in (6)

$$P_{\mathrm{rotor}} = \frac{1}{2}\rho\pi R_{\mathrm{rotor}}^2 v_{\mathrm{wind}}^3 \tag{6}$$

and the aerodynamic torque $\mathit{\Gamma}_{\text{rotor}}$ can then be calculated as

$$\mathit{\Gamma}_{\text{rotor}} = \frac{P_{\text{rotor}}}{\omega_{\text{rotor}}} = \frac{\frac{1}{2}\rho\pi R^2_{\text{rotor}} v^3_{\text{wind}}}{\omega_{\text{rotor}}}\,. \tag{7}$$

The model of turbine blade for this research is shown in Fig. 2 based on Ansys software. This model is used to evaluate the energy based on power equations.

3. Results

The most fundamental measure of a wind turbine's performance is given by its power curve. The wind turbine model developed in the previous section is tested by running the simulation at wind speeds from 1 to 20 m/s, with increments of 1 m/s between runs. As expected, the power output peaks at rated wind speed and then falls due to stalling.

Research data normality was determined through using Kolmogorov-–Smirnov test and the results are presented in Table 1.

Table 1. Results of Kolmogorov—Smirnov test

Significance level	Kolmogorov–Smirnov test	Variable
0.198	1.075	Team participation
0.165	1.116	Organizational commitment
0.169	1.112	Environmental assessment
0.103	1.217	Senior management participation
0.099	1.226	Education status
0.064	1.313	Cultural aspects
0.107	1.210	Change management
0.14	1.030	Strategic alignment
0.053	1.346	Technology development

According to Table 1, data normality reveals that regarding test statistic value and significance level that is larger than 0.05, it is concluded that data are normally distributed; further, the researcher is allowed to use parametric parameters. Thus, according to the test results, the researcher used one-sample t-test to reply research hypotheses stating that identified organizational strategies influence wind energy investment. The results are shown in Table 2.

Regarding that mean senior management participation obtained 12.47, which is larger than mean variable; in addition, as significance level $\sigma = 0.000$ is less than 0.05, it may be stated that senior management participation in human resource planning process is larger than medium. As a result, it can be expressed that senior management participation influences human resource strategic planning process for wind energy investment at confidence level 95 %.

According to the questionnaire, mean team participation obtained 12.42, which is larger than the variable mean; further, as significance level is $\sigma = 0.000$, which is

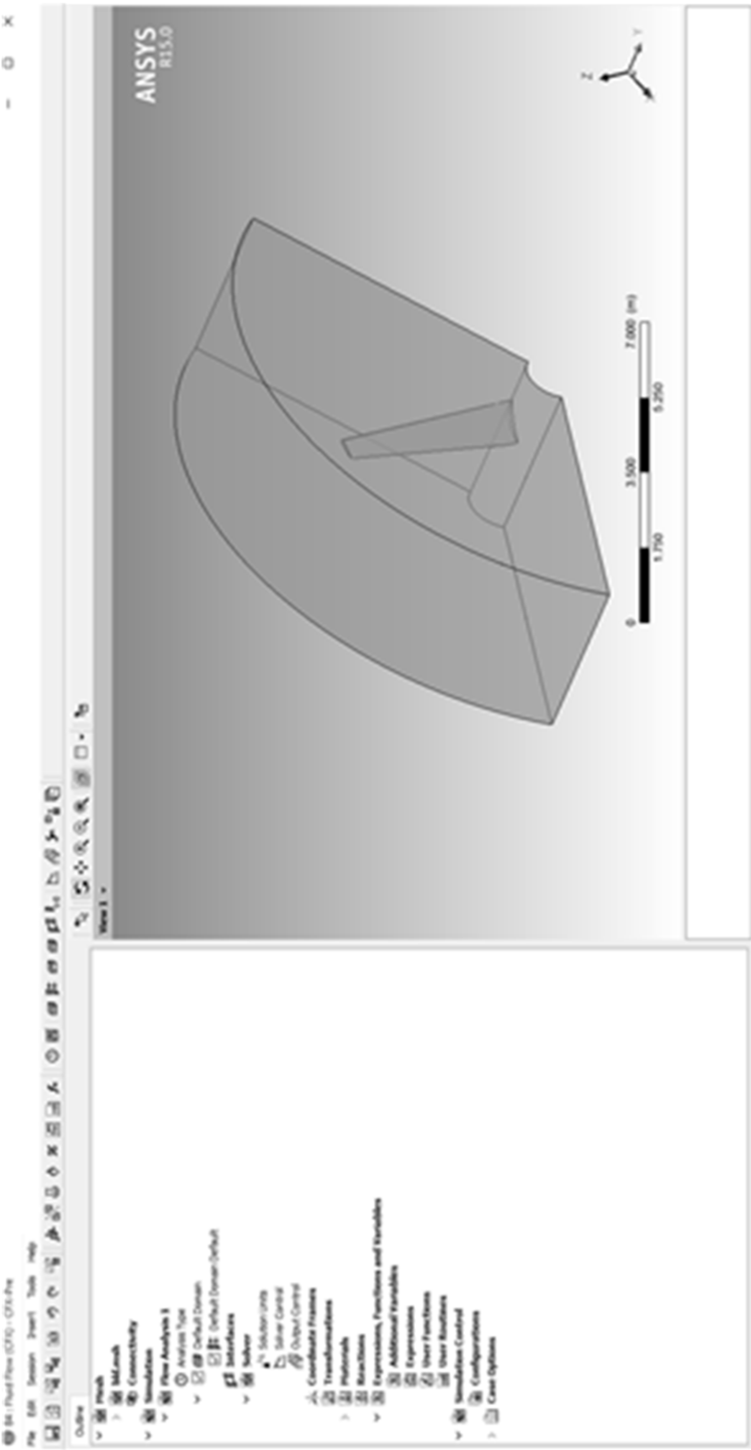

Fig. 2. Wind blade model

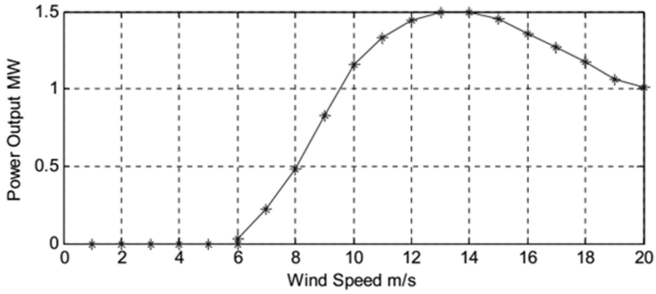

Fig. 3. Power curve for model

smaller than significance level of 0.05; hence, it can be stated that team participation in human resource strategic planning process is larger than medium. As a result, team participation influences human resource strategic planning process for wind energy investment at confidence level 95 %.

Table 2. One-sample t-test results of research hypothesis

Research variable	t-statistic	Significance level	High boundary	Low boundary
Management participation	3.425	0.000	2.259	0.758
Team participation	4.309	0.000	3.354	1.287
Organizational commitment	2.208	0.002	2.379	0.819
Environmental assessment	0.875	0.076	2.257	0.917
Education status	3.209	0.000	2.597	0.928
Cultural factors	4.597	0.003	2.397	0.518
Change management	0.658	0.095	1.297	0.587
Strategic alignment	3.928	0.002	2.394	0.952
Technology development	3.496	0.000	2.824	0.849

Mean organizational commitment obtained 11.97, which is larger than the variable mean. Also, as significance level equals $\sigma = 0.002$, which is less than 0.05, it can be stated that organizational commitment in human resource strategic planning process is larger than the medium. Thus, it is expressed that organizational commitment influences human resource strategic planning process for wind energy investment at 95 %.

Mean environmental assessment obtained 11.24, which is almost equal to the variable mean. Moreover, since $\sigma = 0.076$ is larger than significance level 0.05, it can be stated that environmental evaluation in human resource strategic planning process equals the mid-level. Thus, environmental assessment has no effect on human resource strategic planning process for wind energy investment at confidence level 95 %.

According to the table, mean cultural factors attained 11.93, which is larger than the variable intermediate. In addition, as $\sigma = 0.003$ is less than 0.05, it may be expressed that cultural aspects are larger than the intermediate in human resource strategic planning process. As a result, cultural aspects influence human resource strategic planning process for wind energy investment at 95 %.

Mean change management was measured 14.95 that almost equals the variable mean. According to significance level $\sigma = 0.095$, which is larger than 0.05, it may be declared that change management in human resource strategic planning process equals the median. Therefore, change management has no effect on human resource strategic planning process for wind energy investment at 95 %.

According to the table, mean strategic alignment was obtained 7.6 that is larger than the mean variable. Regarding $\sigma = 0.002$, which is smaller than 0.05, it can be stated that strategic alignment is larger than the mean in human resource strategic planning process. Thus, strategic alignment shows an effect on human resource strategic planning process for wind energy investment at 95 %.

As observed in the table, mean technology development was obtained 16.59, which is larger than the mean variable. According to $\sigma = 0.000$ that is less than significance level of 0.05, it implies that technology development is larger than the mean in human resource strategic planning process. As a result, technology development is effective for wind energy investment in human resource strategic planning process at 95 %.

4. Conclusion

The present research investigated the relationship between nine major organizational factors with strategic planning achievement in Iran grid management for wind energy usage. Finally, the effects of five factors of senior management participation in strategic planning process, senior management knowledge awareness and strategic planning significance, staff team participation in strategic planning process, change management, and proper environmental evaluation in strategic planning process were maintained. Comparing research results with corresponding studies demonstrates consistent results. Factors of staff team participation, management awareness, management participation, change management, and environmental assessment, which have been referred as effective factors of achieving strategic planning in earlier studies, are also true about Khorasan Razavi regional electricity company. However, as earlier mentioned in the literature and research hypotheses, three factors of organizational commitment to strategic planning process and organizational commitment, staff acceptance, and proper databases were confirmed by testing research hypotheses. Now, Khorasan Razavi Regional Electricity Company is one of the national regions consumes more power than it generates due to too many large polluted industrial estates requiring increased electrical energy generation. Thus, it seems necessary that organizational managers and planners to plan for using wind energy, which is highly advantageous as it holds the fastest growth resource comparing other energy sources for power supply. As a result, it must be interested; and further, organizational strategies and infrastructures must be revised for better utilization of the renewable energies.

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