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ARTICLE

INVESTIGATING THE RELIABILITY OF SMALL-SCALE WIND-POWER CONVERSION SYSTEMS CONNECTED TO THE NETWORK

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ABSTRACT

Introduction: *Today, increasing the reliability of power systems is one of the important goals in its various planning. In the meantime, reliability testing in terms of production has particular importance. Increasing arrival of renewable energy sources to the energy generation cycle on the one hand and increase energy consumption on the other hand, reliability indicators find particular importance.* ***Material and method:*** *Therefore, in the present study, with the aim of investigating the reliability of small-scale wind-power conversion systems connected to the network, a possible method was developed to evaluate the contribution of wind turbines to the overall reliability of the entire system. In the initial model, transmission lines have been used to connect the wind farm to the real network.* ***Result and discussion:*** *The basic model used in this research is the 220kV system, 56km. In this paper, the classic model of the production system is expanded in combination with the transmission system. The average power output (mean-COPT) table has also been used to increase the computational velocity which allows for the compilation of LOLE and EUE reliability indices simultaneously. Wind velocity is predicted using the ARMA time series for wind power modeling, and then the power is estimated using wind turbine curve. An appropriate method for reducing model modes is also used and a 5-mode model is proposed. With regard to the constraints of transmission lines in the production of wind power models, the model obtained has between 2 and 5 modes. Conclusion: Using wind power, on the other hand, saves fuel consumption, improves system reliability and enhances environmental issues. It is also very effective in determining the best transmission capacity with regard to the risk and cost of the system.*

KEY WORDS
wind power, wind turbine systems, reliability, renewable energy

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INTRODUCTION

Today, increasing the reliability of power systems is one of the important goals in its various planning. In the meantime, reliability testing in terms of production has particular importance. Increasing arrival of renewable energy sources to the energy generation cycle on the one hand and increase energy consumption on the other hand, reliability indicators find particular importance.

Meanwhile, using wind farms has become more important because of higher energy production and cheaper energy production. For each system and in each project, the first step in the field of reliability engineering is to identify the capabilities of its agents. Reliability engineering must meet the requirements of the tasks that are performed in order to ensure the reliability of the systems of the system, documentation of the design and development of the system, tests, production and performance. Reliability tasks include analyzes schedules, and failures reports. Choosing the type of tasks and the level of work required depends entirely on the importance of the system, its type of function and the defined costs. Major systems required formal reports to fail in the next stages of development while less important systems can conclude with the final test reports [1]

The production system involves many power plants that convert mechanical power into electrical power using energy sources such as coal, gas and water. In most cases, these power plants are in a very large fraction of the load [2]. It provides the required power to the power network and consists of several large power plants. For each system and in each project, the first step in the field of reliability engineering is to identify the capabilities of its agents. Reliability engineering must meet the requirements of the tasks that are performed in order to ensure the reliability of the systems of the system, documentation of the design and development of the system, tests, production and performance. Reliability tasks include analyzes schedules, and failures reports. Choosing the type of tasks and the level of work required depends entirely on the importance of the system, its type of function and the defined costs. Major systems required formal reports to fail in the next stages of development while less important systems can conclude with the final test reports. In general, the most important tasks and routines of reliability have been documented in the standards of the different domains [3].

The distribution network is the last part of the power system that is in direct communication with consumers. This section has many challenges, especially high power losses and low reliability. In this part of the network, the consumption current is at the highest possible, and after that the high network losses are high which leads to the destruction of the voltage profile and increase network cost. Distribution network has the most equipment in terms of diversity and multiplicity compared to other parts of the network. Hence, its reliability level is very low. In this article, due to the random nature of the output of the production units, a probabilistic method for assessing the reliability of a power system of a wind system is presented. The primary model involves connecting the transmission line of a large remote wind farm to a typical network system. Using this method, the risk probability model which is a combination of production model and load model, is constructed and according to that, the important indicators of system reliability such as LOLE and LOEE obtained. In this study, the average capacity abandonment possibility is used. Meanwhile, using wind farms has become more important because of higher energy production and cheaper energy production. In aim of this study is evaluate the reliability of the studied system with the presence of wind farms, in addition to selecting the appropriate model for forecasting wind velocity and wind farm, reliability indicators of the system are also calculated. The simulation experiment was performed on the sample network and the obtained values were analyzed.

LITERATURE REVIEW

Wind turbines with permanent magnetism synchronous generators (PMSG) has efficient configuration for applications with variable velocity. Advantages of using these settings include eliminating dc stimulation, less need for repair and high power over weight. These compositions require a full-fledged transducer to connect to the network, which makes it possible to obtain power from the wind in a range of wind velocity. Different control methods are used to obtain maximum power and maximum power point tracking (MPPT) at the variable velocity of wind turbine [4].

Reference [5] has controlled the optimized performance of a variable velocity winding turbine connected to a DFIG-equipped network with a non-linear control system with two separate targets. In the outer ring, a maximum power point tracking algorithm (MPPT) based on fuzzy logic theory is designed to extract continuous optimal aerodynamic energy. The simulation results indicate the permanent tracking of the MPP point regardless of the turbine velocity, in addition, the proposed slider mode control strategy has interesting features in comparison to the original first-grade slider technique.

Reference (Voldgade) provides an effective plan to improve the DFIG-based turbine capacity under unbalanced voltage drop conditions with the reliability of wind energy conversion systems. This means that the above idea applied during unbalanced voltage drop, SDR resistors only in low voltage phases. Then, the rotor current is controlled in such a way that no unbalance voltage occurs on the stator voltage. An analysis of the reliability of a small size wind system with a permanent magnet synchronous generator is presented in [6]. Such a system is largely influenced by many dependent variables. In this reference, the magnitude of the effect of each variation on the reliability of the system has been investigated.
Reference [7]. applied a DFIG variable velocity based on WECS to generate simultaneous power with harmonic filtering and network reliability. An improved harmonic splitter in the field of time has been used based on a new selector signal detector. The technique for offsetting the entire network stream harmonic components is selected. Simulation for a three-megawatt WECS with DFIG at two different velocity (8 and 12 m/s) has been implemented. The results showed that, in addition to the power, the network flow harmonic filtering was achieved using WECS and 4% total harmonic reduced.

A reference [8] has proposed the DFIG without brush (BDFIG) as a variable alternator in wind turbines. The BDFIG benefits from the DFIG, that is operation in variable velocity, but does not include brushes and slider loops that increase its reliability. The analytical results are presented by simulating the time domain for small wind turbine generators, as well as the experimental results of voltage drop for BDFIG with a power of 250 kV presented. In, the effects of voltage drops due to DFIG error to overcome network errors and improve reliability are studied. A wide range of duration and loss depths are considered. It has been observed that the effect of the duration of the drop is changed periodically. The effect of drop depends on duration and depth, as well as the process of eliminating the error. Two methods have been used to analyze this: a distinct drop and a sudden drop. The voltage range of the converter of the rotor is intended to show the rotor current status in this analysis.

Mohanti et al [9] proposed a new method for compensating reactive power in a micro-network by having a DFIG based on a wind-diesel system to enhance the paradigm of the hybrid system voltage and increase reliability indices. UPFC is used as one of the FACTS devices to improve the control of reactive power failure and system stability. The small signal system of the wind-diesel system, the DFIG-based wind turbine system, UPFC, and controllers for this analysis are designed. In addition, voltage change and reactive power compensation are investigated by combining the proposed ANFIS with the UPFC controller.
Reference [10] focuses on the stability analysis of the oscillation and reliability of a wind turbine. The exact mathematical analysis of the wind turbine has been expanded with the controller loops. Also, the Huff branching is considered as a key parameter. They are used to guide the regulating of DFIG parameters to ensure sustainable operation. The results of the dynamic stability analysis of an 80 MW coastal wind turbine connected to the power network by a high voltage direct current (HVDC) line are presented in [11].

The wind turbine studied has been simulated using an excited wind turbine equivalent. The systematic analysis was carried out using the frequency domain method based on the calculation of special values and time domain design based on nonlinear model simulations. Modeling the DFIG system for wind turbine use is the main challenge of reference [12]. The PSCAD / EMTDC software has been used for the superiority of the proposed-model and the dynamic response to the voltage drop is discussed with the behavior. An analysis for wind generator DFIG for operation in unbalanced voltages is presented in [13].
The DFIG system is modeled by the positive synchronous reference framework. The behavior and operation of the generator system and the network side converter are shown under unequal conditions with the definition of oscillatory power expressions in the synchronous reference framework. This model allows active and reactive power control using the direct power control technique. It is shown that by considering the DFIG model in the synchronous reference, exchange of power has been simplified. In addition, using the proposed model, the oscillation of the stator output power is facilitated using the GSC.

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Modeling the system and evaluating the method

Wind velocity modeling

The wind power productive has a direct relation with the cubic of the wind velocity. This means that it is necessary to study the effect of wind power on the reliability and cost of a system for accurate modeling of wind velocity. By changing the time and geography location, wind velocity changes continuously. Therefore, simulating a wind model, simulates the wind velocity for a specific region in a given time interval. To simulate the hourly wind velocity, an ARMA time series selected for the wind farm was formulated as math:

$$y_t = \varepsilon_t + \sum_{i=1}^{p} \varphi_i y_{t-i} + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} \qquad (1)$$

In this regard, yt is the amount of time series at time t, and are recursive and motor parameters. is normal white noise with average zero. The simulated SWT wind velocity at t can be calculated according to equation (2) using the mean velocity and standard deviation and the value at time series calculated as follows:

$$SW_t = \mu_t + \sigma_t \times y_t \qquad (2)$$

The average hourly wind velocity and standard deviation of data for the Zafarana area were collected by the NREA and a computer program written to use wind velocity data, determine the exact ARMA model (p, q) to be used to simulate wind velocity. This model represents the first step in modeling the wind system.

Modeling the WTG system

The Zafarna wind farm is made up of three types of units and has an installed capacity of 425.82 MW. Modeling WTG system requires the combination of the wind velocity model described above with the WTG generation capability for all types of WTGs.

Productive wind power

The main features affecting the amount of power produced by WTG are cut-off velocity Vci, high cut-off velocity Vco, nominal velocity Vr, and nominal power Pr. The generated wind power varies nonlinearly with variations in wind velocity and can be determined by the WTG power curve, which is formulated mathematically as follows:

$$P_t = \begin{cases} 0 & 0 \le SW_t \le V_{ci} \\ A + B \times SW_t + C \times SW_t^2 & V_{ci} \le SW_t \le V_r \\ P_r & V_r \le SW_t \le V_{co} \\ 0 & V_{co} \le SW_t \end{cases} \qquad (3)$$

In this case, Pt is the output power at t and the coefficients A, B, C are determined from the upper and lower cutoff rates.

Productive wind power model

Wind farm production capacity consists of a number of different modes of production power and the corresponding probabilities of each of them. The probability of the availability of a Pwi simulated wind speed SWi is calculated by the following equation:

$$P_{wi} = \frac{N_i}{(N \times 8760)} \qquad (4)$$

In this case, N is the number of simulated years and Ni is the number of wind speeds in the range (SWj,, SWj+1), which:

$$SW_i = \frac{(SW_j + SW_{j+1})}{2} \qquad (5)$$

The Pi power generated by each WTG in the wind farm is calculated by Eq (3) and then summed together to determine the wind farm production potential, which is based on the amount of wind power generated by the WPi wind farm and the probability of occurrence of the Pi. The amount of WPi corresponding to the SWi wind speed is calculated from equation (6):

$$WP_i = \sum_n P_i \qquad (6)$$

In this case, n is the number of wind turbines (WTGs) in the wind farm.

EPO is defined as the average long-term output power and it is an indicator for assessing the usefulness of the wind farm. This index is calculated from the following equation:

$$EPO = \sum_{i=1}^{m} WP_i \times p_i \quad (7)$$

In this case, m is the number of states of production.

The number of model states obtained is high. Therefore, an appropriate method has been used to provide a reduced equivalent model of wind farm. The average wind speed for this geographic region is between 9 and 9.7 m/s, and the standard deviation is the hour within the range of 3.5 to 3.6 m/s.

The amount of cut-off velocity, nominal velocity and cut-off velocity of each wind turbine (WTG) are in the range of 2.5, 4 and 4 m/s, 13, 13 and 17 m/s, 25, 19 and 25 m/s. The 5-state model obtained for the wind farm is shown in [Table 1].

Table 1: Productive wind power model

The probability of each mode	Productive wind power mode $WP_t(\%)$
0.070210	0
0.059460	25
0.116850	50
0.244460	75
0.509020	100

Wind turbine system model

The next step in the evaluation process is to determine the model of wind farm productive power at the network connection point. In this model, the transmission line model is considered, which includes the power transmission power and the possibility of out-of-service lines, which are included in the wind farm productive power model. As stated in equation (8), the available wind power at the network connection point (WPGi) is limited by the capacity of the transmission lines Tcap:

$$WP_{Gi} = WP_i, \quad for \quad WP_i < T_{cap} \quad (1)$$
$$WP_{Gi} = T_{cap}, \quad for \quad WP_i \geq T_{cap}$$

Also, the probability pGi for producing the WPGi mode is calculated from Equation (9):

$$p_{Gi} = U_T + (1 - U_T) \times p_i \quad for \quad WP_{Gi} = 0 \quad (2)$$
$$= (1 - U_T) \times p_i \quad for \quad WP_{Gi} < T_{cap}$$
$$= (1 - U_T) \times \sum_{j=1}^{s} p_j \quad for \quad WP_{Gi} = T_{cap}$$

In this connection, U_T is the probability of the exit of the transmission line from the network, and s is the total number j of the productive mode limited by the capacity of the transmission lines.

In this research, the failures of the transmission system (λ) and the average repair time (r) from the Egyptian electricity company have been extracted. The probability of unavailability of the transmission system is calculated 0.066. The combined wind power model combines with the unavailability of a transmission system of 2 to 5 modes depending on the capacity of the transmission lines and the capacity of the wind farm. These models, which are computed from computer running, are shown in [Table 2].

Table 2: Suspended model of productive wind power

Productive wind power mode $WP_t(\%)$ (MW)	The probability of each mode
Two modes model	
0	0.1843
100	0.8057
Three modes model	
0	0.1943
130	0.4554
250	0.3503
Four modes model	
0	0.1943
130	0.4554
260	0.3117
350	0.0386
Five modes model	
0	0.1943
130	0.4554
260	0.3117
390	0.0375
520	0.0012

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Thus, equations (6) to (9) are used to determine the different modes of productive wind power and the probability of occurrence of each mode. This model is used to calculate EPO according to equation (10).

$$EPO = \sum_{i=1}^{m} WP_{Gi} \times p_{Gi} \qquad (10)$$

System risk modeling

The overall model of the productive system, comprised of the combination of traditional production units and wind power, is ultimately blended with the load model to determine the system risk and energy indicators. The load on the Egyptian electricity system varies with time change, and these changes can be modeled by the load model. [Fig. 1] shows the load curve model.

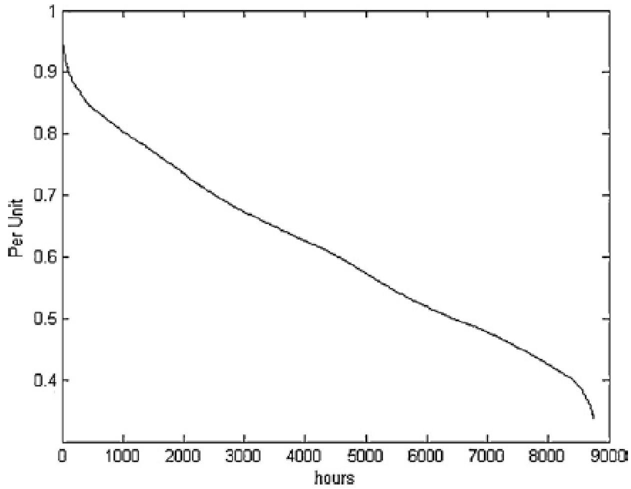

Fig. 1: Egyptian annual load variation curve

Integration adequacy assessment and Risk Indicators

[Fig. 2] shows the overall software process used to assess the system's adequacy. This program calculates system reliability indicators, including the expected unprotected burden (LOLE), as well as energy indicators such as the amount of expected unloaded load (LOEE) and the amount of energy indicators including expected energy levels (EES) for each productive unit calculated. These indicators are used to assess the reliability and cost of community units of wind units with traditional productive units and transmission systems.

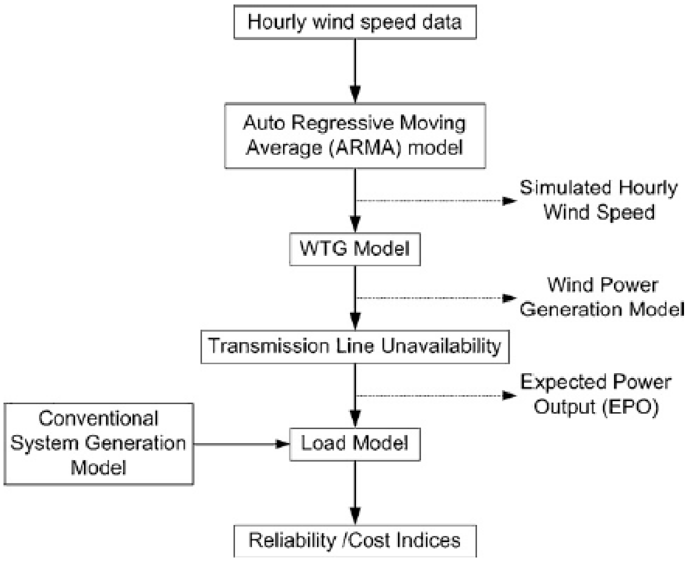

Fig. 2: Flowchart of the evaluation process used

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Evaluation of reliability and cost

The use of wind power in a traditional power system has advantages such as the following:
Saving wind turbines for fuel consumption
The amount of fuel savings is calculated by determining the energy deviation. The energy deviation is equal to the amount of energy expected by wind resources. The energy provided by the wind farm changes the cost of fuel needed and is calculated from Equation (11):

$$FOW = EES_w \times FC \quad (3)$$

In this equation, FOW is the fuel saving rate by wind turbine, EES_w the amount of energy supplied by WTG in MWh and FD is the average fuel cost per $/MWh.

Environmental benefits caused by the use of wind turbines

Wind power technology and wind power costs are much more cost effective than generating power by traditional sources. The Wind Power Productivity Index (WPPI) has been used to calculate the environmental benefit of wind power, which is estimated at 1 $/kWh.
The monetary value of environmental benefits is calculated using equation (12) as follows:

$$BOI = EES_w \times WPPI \quad (4)$$

In this equation, the BOI is profit index, which is in dollar.
3-2-1 Reliability
In addition, the wind power in the traditional system can be beneficial by providing additional energy to the system and reducing the cost of payments to definite subscribers (ECOST). The easiest way to estimate ECOST is given in Equation (13) [14]:

$$ECOST = \text{IEAR} \times \text{LOEE} \quad (5)$$

The IEAR show the evaluation of the cut-off energy and 3.63 $ /kWh is non-energized power. LOEE is also defined as the amount of energy not provided by the sources of production (EENS). Adding wind power to the power system improves overall system performance and increase system reliability. This sentence can be numerically calculated by reducing the LOEE value obtained from Eq. (14):

$$\Delta\text{LOEE} = \text{EENS} - EENS_w$$ (Error! No text of specified style in document.6)

In this equation, ΔLOEE is the reduction in LOEE of the system as a result of wind use, EENS is the amount of energy not provided before adding wind and $EENS_w$ is the amount of energy not provided after adding wind power. The reduction in cost for subscribers or the amount of available profits from ECOST savings can be calculated according to equation (15):

$$BOC = IEAR \times \Delta\text{LOEE}$$ (Error! No text of specified style in document.7)

BOC is the amount of profit earned by saving ECOST in dollar. Thus, the total benefit (B_w) of wind power is calculated using Equation (16) as follows:

$$B_w = EES_w(\text{FC} + \text{WPPI}) + \text{IEAR} \times \Delta\text{LOEE}$$ (Error! No text of specified style in document.8)

RESULTS

The Egyptian power system consists of 165 manufacturing unit with a production capacity of 21516 MW. The annual peak charge for this country is 19700 MW. System information and information about the reliability of the system's units are given in [Table 3]. The Zafarana wind farm makes up 1,979% of this power. According to the method presented in [Fig. 2], this section of the reliability assessment is used to find the best transmission system capacity. For this study, EPO, LOLE, LOEE and EES indicators were used to study reliability.

Investigating the effect of the transmission line capacity

By increasing the Zafarana wind farm, the reliability of the system has increased. But the reliability of the wind system depends on the communication line that connects it to the system. [Fig. 3] shows the increase in reliability of the system by increasing the capacity of this communication line. But reliability increases with increasing line capacity. This figure indicates that the EPO for a 150 MW line is approximately 127.848 MW, and for a 600 MW line capacity is equal to 304.642 MW.

In this figure, the capacity of the zero line indicates that there is no connection between the wind farm and the system. Also, the LOLE value of the main power system of Egypt without wind power is 28.98813 h/yr. [Fig. 4] shows that increasing the line capacity is more than 450 MW that has not affected the reliability of the system.

Table 3: Information on the production units of the Egyptian power system

Unit Capacity (MW)	Unit type	Number of units	FOR	MTTF(h)	MTTR(h)
11.30	G	1	0.78384	126.14400	457.42616
11.60	G	1	0.78395	126.14400	457.42616
14.28	H	6	0.05633	5135.11200	306.54618
16.00	H	4	0.05633	5135.11200	306.54618
23.96	G	2	0.60355	183.960000	280.05672
24.50	C	12	0.06941	3836.00400	286.12865
24.60	G	1	0.60371	183.96000	280.24123
24.72	C	8	0.06666	3836.00400	273.98078
26.50	S	1	0.09369	4239.84000	273.98078
30.00	S	5	0.09369	4239.84000	438.29941
32.30	G	5	0.60371	183.96000	280.24123
33.00	S	2	0.09369	4239.84000	438.29941
33.30	G	4	0.60371	183.96000	280.24123
33.50	G	3	0.60371	183.96000	280.24123
45.92	C	1	0.09381	4239.84000	438.91242
45.94	C	1	0.06666	3836.00400	273.98078
46.00	H	7	0.04728	4920.49200	244.19637
50.00	G	1	0.32611	400.33200	193.72776
55.00	C	1	0.06666	3836.00400	273.98078
58.55	C	3	0.06666	3836.00400	273.98078
60.00	S	4	0.09369	4239.84000	438.29941
65.00	S	3	0.09369	4239.84000	438.29941
67.50	H	4	0.04728	4920.49200	244.19637
87.50	S	4	0.09369	4239.84000	438.29941
110.00	G	3	0.32586	400.33200	193.72776
110.00	C	1	0.06666	3836.00400	273.98078
110.00	S	4	0.07624	5745.68400	474.21369
132.00	C	6	0.06666	5745.68400	273.98078
136.00	C	3	0.06666	3836.00400	273.98078
150.00	S	10	0.07624	5745.68400	474.21369
175.00	H	12	0.04728	4920.49200	244.19637
210.00	S	2	0.09066	6547.22400	652.71720
250.00	C	16	0.06666	3836.00400	273.98078
300.00	S	3	0.05929	6230.98800	392.72067
311.00	S	1	0.05929	6230.98800	392.72067
312.00	S	2	0.05929	6230.98800	392.72067
315.00	S	4	0.05929	6230.98800	392.72067
320.00	S	6	0.05929	6230.98800	392.72067
330.00	S	2	0.02917	6230.98800	391.84406
341.25	S	4	0.05929	6230.98800	392.72067
627.00	S	2	0.06649	6806.52000	484.80407

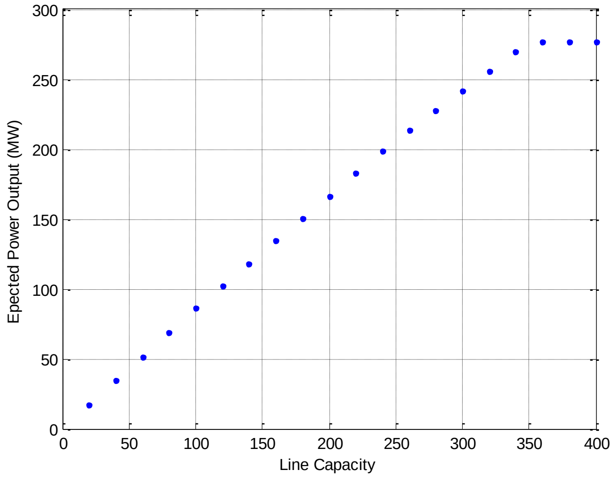

Fig. 3: Expected Output Power (MW)

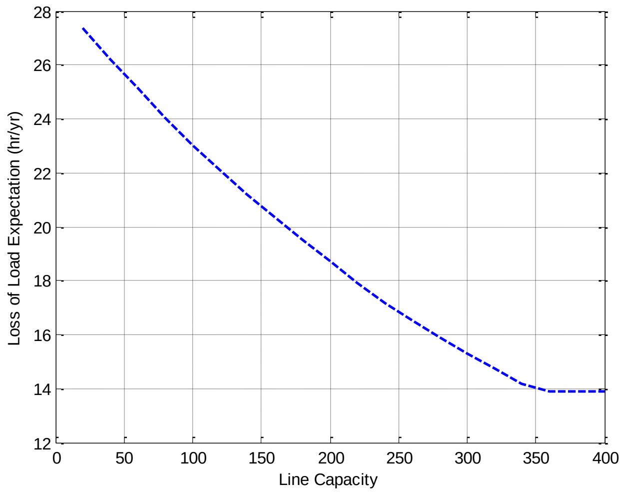

Fig. 4: Expected deadline load by increasing line capacity

Economic review of the wind power transmission system

Making the final decision about the best transmission system requires a comparison between cost and system reliability. In order to determine the best transmission capacity, the benefit from wind power transmission is compared with the cost of investment in the transmission system for different transmission capacities. Investment in the transmission line generally increases linearly with the increase in transmission capacity. The cost of investing in the 220 kV and 300 MW system is equal to 0.69 million dollars $/km.

A linear relationship has been used to estimate the cost per kilometer of transmission line for different capacities. Also, the annual amount of the investment is based on the average life expectancy of 45 years. Assuming that after the traditional large production units, wind resources are used to supply the load, the amount of fuel saved is calculated. The average value of 3.75 $/MWh in this study is considered for fuel costs and the wind power producing revenue is assumed to be 0.01 $/kWh. The IEAR value is 3.63 $/kWh and the profit value using (16) is calculated.

Investigating the effect of the transmission line development

The net profit resulting from the development of the transmission line above 50 MW is shown in [Fig. 5]. The benefit of connecting wind power through the transmission line is calculated by equation (16). The difference between the total cost of the investment and the total net profit, net profit is calculated. The profit in the capacity of the 350 MW line has reached its highest level. [Fig. 5] shows that by increasing the line capacity, the net profit rate is reduced rapidly. [Fig. 4] also showed that there was no reliability in capacities greater than 450 MW. Also, in order to determine the future conditions of the system, the decision should be made for the best capacity of the transmission line.

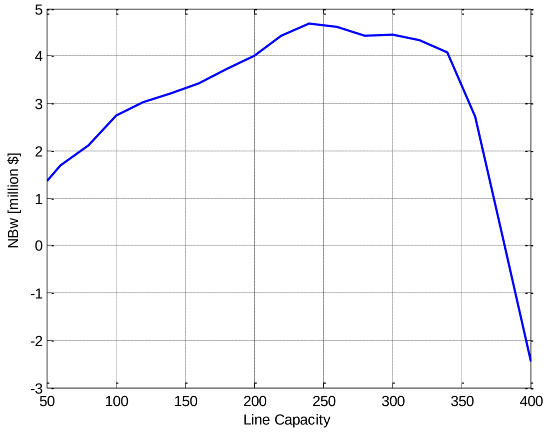

Fig. 5: Net profit with the development of the transmission line

The use of the n-1 method, considering the random nature of the generated wind power, is not a prime means for planning the transmission system, and therefore this method cannot be used to plan a power system with wind power. In this section, a feasible method is proposed based on reliability assessment methods and cost to assess the impact of wind power transmission on system reliability. The system model and methods for using the limited transmission line in the HL-I study system are presented. The wind power model has been gathered at the network connection point with the traditional Egyptian power system model. A computer program has been written to evaluate the reliability of the system using numerical results. The main indicators that can be calculated from this program are EPO, LOLE, LOEE and EES indicators. By adding wind power to the traditional power system, the reliability indicators of the transmission capacity increased [15]. However, increasing the capacity of the lines will reduce the benefits of increasing reliability. Wind power reduces fuel consumption, reduces system shutdown time and reduces environmental degradation. Economic analysis of reliability indicates that these benefits are limited to a certain range of transmission line capacity. Also, from a specific range, there is no more wind power can be used in the system, and thus, with increasing wind power usage in the system, these relative benefits are reduced [16].

CONCLUSION

Energy savings and the use of renewable energy have become more important given the increasing need for energy and the completion of fossil fuels and the concern for greenhouse gas emissions. Production through new energies like the sun and wind is the main solution to the energy crisis. The total installed solar capacity in 2012 was 100 GW. This amount for wind power has reached 283 gigawatts at the same time. The growing use of new energies has led to widespread use of electronic power, in which electronic power converters play an important role in extracting power from renewable sources. Power electronics equipment can generate raw energy from new energies to an arbitrary power supply; controllable voltage and frequency is converted to usable energy in the power network.

For wind systems, the electronic converter is the intermediate power between the wind turbine and the power network, and it can convert the raw power generated by the power turbine compatible with network and along with this conversion, tasks such as improving network power quality, extracting maximum power from the network, and active and reactive power control.

For solar systems, the power electronic converter also has the power to convert the dc power output of the panels to the optimal network ac power. Of course, along with those tasks, there is also a maximum power output. Given the expansion of renewable resources in the network, the reliability of these resources has great importance and because the exits of these resources, which are usually installed near loading centers, will shut down the network's reliability.

Proper design of these systems will have a direct impact on the reliability of these systems, from the point of view of the proper selection of active and inactive elements and the proper design of the ventilation system. Also, it is also important to study the methods that can be used to eliminate the power of the converter output after the failure of the electronic converters. This property is referred to as fault-tolerant converters.

In the article, a review on reliability and important indicators on this field was carried out. Then, the method of assessing the reliability of electronic power converters was presented. In addition, the power extraction methods from wind turbines were investigated. In order to inject PMSG from the active power to the three-phase network, a diode rectifier with an augment converter and inverter should be used. The duty of the inverter is to adjust the DC bus voltage and the duty of the converter to adjust the output voltage of the rectifier in an amount in which the maximum power of the PMSG is extracted. This system was simulated. Then, the reliability of each single converter, including incremental converter, rectifier and inverter was investigated. Incremental converter to improve the reliability of the converter and Interleaved Boost converter to reduce the flow was used. Simulation results showed the effect of wind speed on power and losses, as well as reliability, and the accuracy of the calculations was confirmed.

CONFLICT OF INTEREST
There is no conflict of interest.

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FINANCIAL DISCLOSURE
None

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