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POTENTIAL OF ELECTRICITY GENERATION ON THE WESTERN COAST OF MEDITERRANEAN SEA IN EGYPT

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A technical and economic assessment has been made of the electricity generation by wind turbines located at three promising potential wind sites: Sidi Barrani, Mersa Matruh and El Dabaa in the extreme northwest of Egypt along the Mediterranean Sea. These contiguous stations along the coast have an annual mean wind speed greater than 5.0 m/s at a height of 10 m. Weibull's parameters and the power law coefficient for all seasons have been estimated and used to describe the distribution and behavior of seasonal winds at these stations. The annual values of wind potential at the heights of 70–100 m above the ground level were obtained by extrapolation of the 10 m data from the results of our previous work using the power law. The three stations have a high wind power density, ranging from 340–425 to 450–555 W/m^2 at the heights of 70–100 m, respectively. In this paper, an analysis of the cost per kWh of electricity generated by two different systems has been made: one using a relatively large single 2 MW wind turbine and the other – 25 small wind turbines (80 kW, total 2 MW) arranged in a wind farm. The yearly energy output of each system at each site was determined, and the electricity generation costs in each case were also calculated and compared with those at using diesel oil, natural gas and photovoltaic systems furnished by the Egyptian Electricity Authority. The single 2 MW wind turbine was found to be more efficient than the wind farm. For all the three considered stations the electricity production cost was found to be less than 2 € cent/kWh, which is about half the specific cost of the wind farm.

Key words: *Wind characteristics; Weibull's parameters; Specific wind power; Electricity generation costs.*

1. INTRODUCTION

Wind power is one of the most attractive sources of renewable energy; it is also a potentially valuable source of energy in the Third World in general and in Egypt – which is totally dependent on exported energy – in particular. Egypt's energy resources are limited in oil and petroleum products and highly limited in natural gas; at the same time, Egypt is rich in renewable energy resources such as solar, geothermal and wind energy. Among all, wind seems to be the most suitable renewable energy resource for electricity generation. The wind energy in Egypt has not yet been studied thoroughly. Some attempts were made to analyze Egypt's wind potential [1, 2–6], and some experimental works [7, 8] were conducted. Also, industry and manufacturing of wind turbines are not currently developed in Egypt, and these are therefore supplied by other countries.

In our previous article [1], a technical assessment of the wind energy potential in Egypt was made. The assessment entailed studies of 10 coastal sites from west to east along the coast of the Mediterranean Sea in Egypt. The contiguous stations: Sidi Barrani, Mersa Matruh and El Dabaa were indicated in [1] as the three most promising sites along the western coast of Mediterranean Sea, so we will focus on these sites in this study .

In this article, possible applications of two different systems for electricity generation at the mentioned three stations and the per kWh cost analysis for each of them are discussed.

2. ANALYSIS OF WIND DATA

Figure 1 shows the location of the three selected stations along the cost of Mediterranean Sea in Egypt. The measurements of monthly wind speed were taken at a height of 10 m above the ground level and in an open area. The Egyptian Meteorological Authority provided the data for a period of more than 10 years. Table 1 lists the mean monthly averages of wind speed and wind directions as well as the annual means for Sidi Barrani, Mersa Matruh and El Dabaa stations. The table indicates that these stations have an annual mean wind speed greater than 5.0 m/s at a height of 10 m, with the main wind direction being northwest.

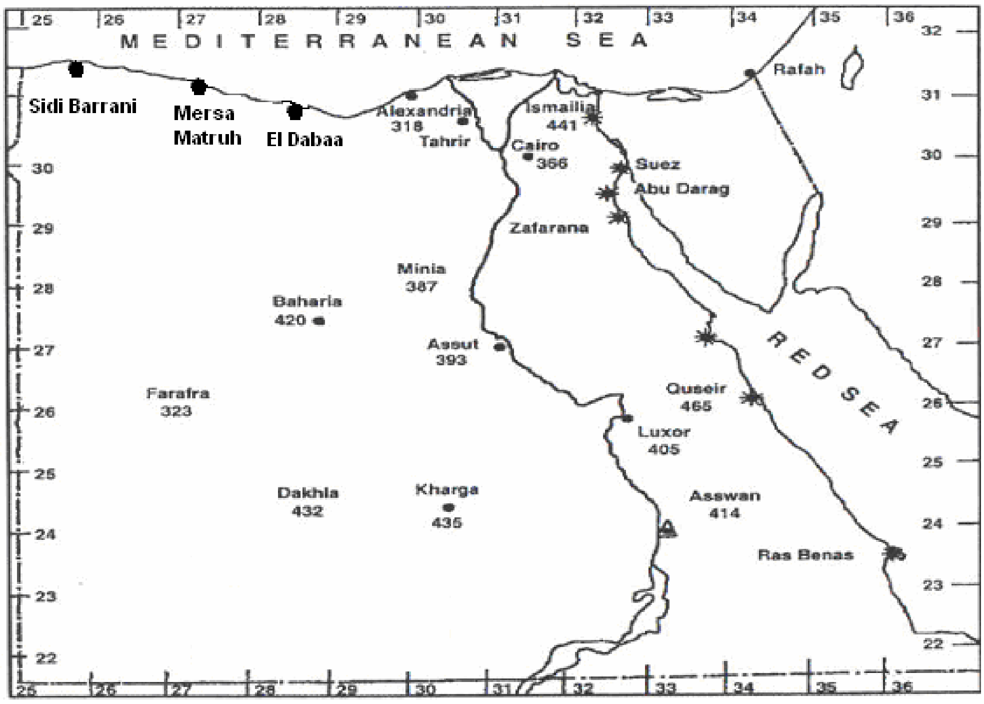

Fig. 1. Distribution of meteorological stations over Egypt.

Mean monthly wind speeds for different seasons of the year are plotted in Fig. 2. It can be taken that high wind speeds occur in the winter and spring seasons. This may be due to the Mediterranean Sea secondary depression [3]. During the winter season, the wind speed level at the three stations reaches high values – of 5.5–6.1 m/s. The maximum mean wind speed (6.1 m/s) occurs at Mersa Matruh during January and February. In the spring season, the three sites have high values

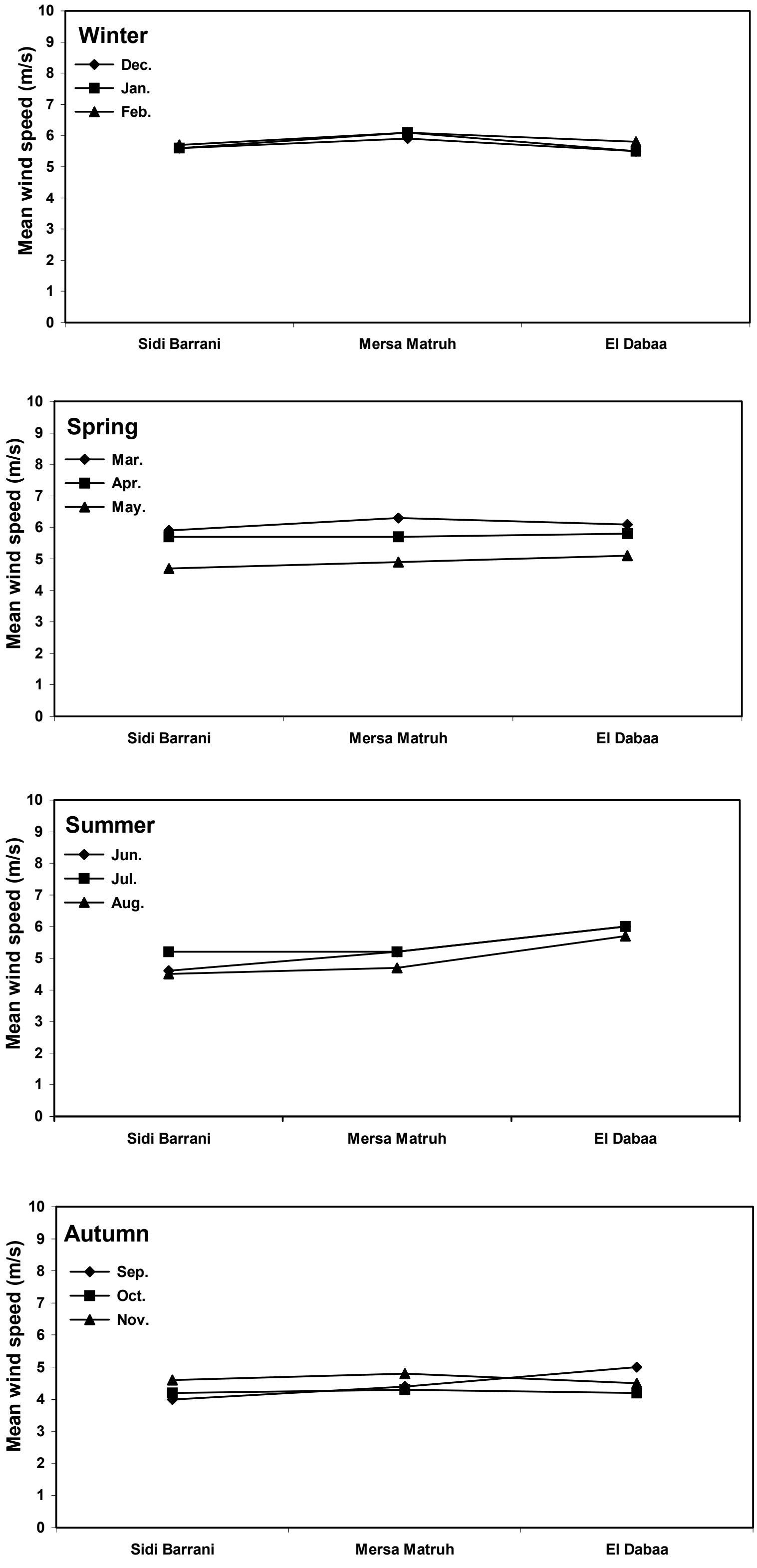

Fig. 2. Mean monthly wind speeds at different seasons of the year for all stations.

of wind speed (4.8–6.1 m/s), where the maximum value is recorded at Mersa Matruh, with 6.3 m/s in March. During the summer season, the wind speed level reaches 6.0 m/s at El Dabaa in June and July. For the autumn season, the maximum value of mean wind speed is recorded to be 5.0 m/s at El Dabaa in September [1].

One important characteristic which could be derived from Fig. 2 is: the curves of mean monthly wind speeds for all seasons of the year are very similar at the three sites, and the variation of their values is very small. This confirms the stability of weather conditions at these contiguous sites throughout the year.

3. MATHEMATICAL ANALYSIS

To estimate Weibull's parameters (seasonal shape parameter k, and scale parameter c) the method of Weibull's probability was applied, which can be described by the following equation [9]:

$$\ln[-\ln(1 - F(V))] = k \ln V - k \ln c. \tag{1}$$

Plotting ln (V) against ln [–ln (1 – $F(V)$)] should yield a straight line. The gradient of the line is k, and the intercept with the y-axis is $-k \ln c$.

Then, the values of power law coefficient (n) can be evaluated based on those of scale parameter (c_{10}) at the standard anemometer height of 10 m by the following equation [10]:

$$n = [0.37 - 0.0881 \ln c_{10}]. \tag{2}$$

In compliance with recommendations of the World Meteorological Organization (WMO), we have chosen a height of 10 m above the ground level. The use of Hellman's exponential law under two important conditions: stability of the atmosphere and modest roughness of the site [5, 11, 12], gives the following expression:

$$\mathrm{V}_{\mathbf{h}} = \mathrm{V}_{\mathbf{10}}\left(\frac{h}{10}\right)^{\alpha}, \tag{3}$$

where α is the roughness factor (usually in the range $0.05 \le \alpha \le 0.5$).

In this analysis, $\alpha = 0.25$ is the standard value for the Egyptian terrestrial and wind conditions [1, 6].

Since the influence of height on the air density for the elevations under consideration is negligible, the power density of the wind above the ground level will be mainly affected by the increase in the wind speed with height [6, 13, 14].

Hence,

$$\mathbf{P_h} = \mathbf{P_{10}}\left(\frac{h}{10}\right)^{3\alpha}, \tag{4}$$

where $\mathbf{P_{10}}$ is the corrected wind power at a height of 10 m.

4. RESULTS AND DISCUSSION

4.1. Seasonal power law coefficient and Weibull's parameters

Table 2 gives the Weibull parameters: seasonal shape parameter k, and scale parameter c, at 10 m height (the values of c and k for a whole year are shown in

Table 1

Mean monthly and annual wind speed (m/s) and its direction (at a height 10 m)

Station	Month												Annual mean (m/s)	Wind direction
	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.		
Sidi Barrani	5.6	5.7	5.9	5.7	4.7	4.6	5.2	4.5	4.0	4.2	4.6	5.6	5.0	330 NW
Mersa Matruh	6.1	6.1	6.3	5.7	4.9	5.2	5.2	4.7	4.4	4.3	4.8	5.9	5.3	330 NW
El Dabaa	5.5	5.8	6.1	5.8	5.1	6.0	6.0	5.7	5.0	4.2	4.5	5.5	5.4	330 NW

Table 2

Seasonal power law coefficient and Weibull parameters at 10 m height.

Station	Winter			Spring			Summer			Autumn			Annual mean		Whole year	
	$n \cdot 10^{-2}$	c (m/s)	k	$n \cdot 10^{-2}$	c (m/s)	k	$n \cdot 10^{-2}$	c (m/s)	k	$n \cdot 10^{-2}$	c (m/s)	k	c (m/s)	k	c (m/s)	k
Sidi Barrani	22.61	5.12	4.00	25.88	3.53	0.82	24.06	4.34	2.31	23.94	4.40	1.38	4.36	2.13	4.27	1.47
Mersa Matruh	22.27	5.32	2.40	23.36	4.70	2.00	23.94	4.40	1.81	24.02	4.36	1.74	4.70	1.99	4.27	1.14
El Dabaa	21.82	5.60	0.37	24.78	4.00	1.16	22.14	5.40	5.67	24.85	3.97	1.33	4.72	2.22	4.02	1.19

Fig. 3). They are calculated by Eq.(1), using the monthly percentage frequency of the mean monthly wind speeds from Ref. [2] of the three stations: Sidi Barrani, Mersa Matruh and El Dabaa.

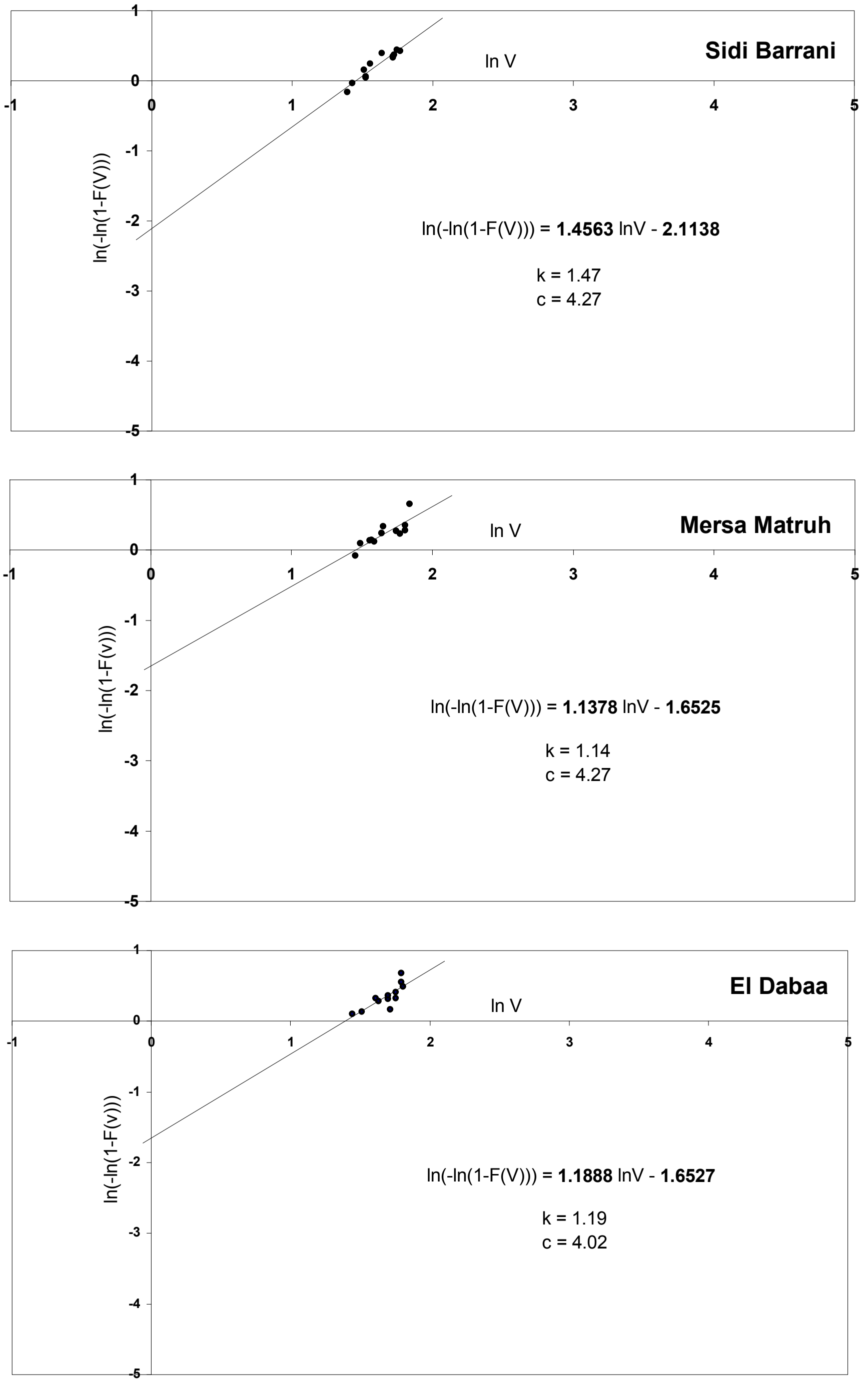

Fig. 3. Monthly observed values of ln (–ln (1 – $F(V)$)) plotted against ln V, for three stations, through which the Weibull parameters are estimated.

Also, the power law coefficient (n) for all seasons is calculated by Eq. (2), with the results given in Table 2. From this table we can derive the following:

1. The values obtained for (n) in all seasons at the three stations are small for high speeds (c_{10}). These agree with Justus *et al.* [15], who concluded that at high wind speeds the exponent (n) would equal to ~ 0.15, closely corresponding to the 1/6 (0.17) or 1/7 (0.14) power law often assumed for neutral stability (high wind) cases. This argument breaks down above 100 m.
2. Small values of k obtained in the autumn and spring seasons indicate widely dispersed data, i.e. the data tend to be distributed uniformly over a relatively wide range of wind speeds [16]. This has a positive implication as to the wind power generation because this means that at the three stations the winds are strong enough to operate a wind turbine for at least a short period.
3. For large values of k in the winter and summer seasons at the three sites the majority of the wind speed data tend to fall around the mean wind speed, and if this speed is high, the power generation is possible for most of the time.
4. The data for the El Dabaa station in the summer season are: high values of mean wind speed v_{10} = 5.90 m/s, c_{10} = 5.40 m/s, and k = 5.67 as given in Tables 1 and 2. Hence, the wind speed in summers is sufficient for high power generation.

4.2. Extrapolation of the data for wind power density at various heights

Using the corrected monthly values of wind power $\mathbf{P_{10}}$ available at Sidi Barrani, Mersa Matruh and El Dabaa stations at a height of 10 m given in [1] and substituting these values into Eq. (4), we obtain the annual wind power at the heights of 70–100 m. The results are presented in Table 3. We therefore can conclude that: the density of power derived from the wind is ranging from 340 to 425 W/m^2 at the height of 70 m and 450 to 555 W/m^2 at the height of 100 m. This result is similar to the power density data of European countries [6, 7].

Table 3

Annual mean corrected wind power at height of 10, 70 and 100 m

Station	$\mathbf{P_{10}}$ (W/m^2)	$\mathbf{P_{70}}$ (W/m^2)	$\mathbf{P_{100}}$ (W/m^2)
Sidi Barrani	79.8	343.4	448.7
Mersa Matruh	94.3	405.8	530.3
El Dabaa	99.2	426.9	557.8

Also, at these contiguous stations along the western cost of Mediterranean Sea in Egypt the wind power density is as high as in the Denmark inland (Vindeby). So, the future of these sites is seen as the use of large wind turbines with a capacity of at least 1000 kW for electricity generation [1].

5. APPLICATIONS OF WIND ENERGY FOR ELECTRICITY GENERATION

Typical applications of wind energy at these stations are electricity generation and water pumping using wind turbines (the Nile river region in Egypt, see Fig. 1). A technical and economic assessment of the electricity generation by two turbines with capacities 300 and 1000 kW at the three sites in Egypt was made in [1].

In this section, the possibility of generating electricity using wind power at Sidi Barrani, Mersa Matruh and El Dabaa is described. Two different systems were applied: a single *Repower MM82* wind turbine of high rated power (2000 kW), and equivalent 25 small *Lagerwey LW 18/80* wind turbines, 80 kW rated power each, arranged in a wind farm of 2 MW total power. The characteristics of these different wind turbines are shown in Fig. 4 and Table 4.

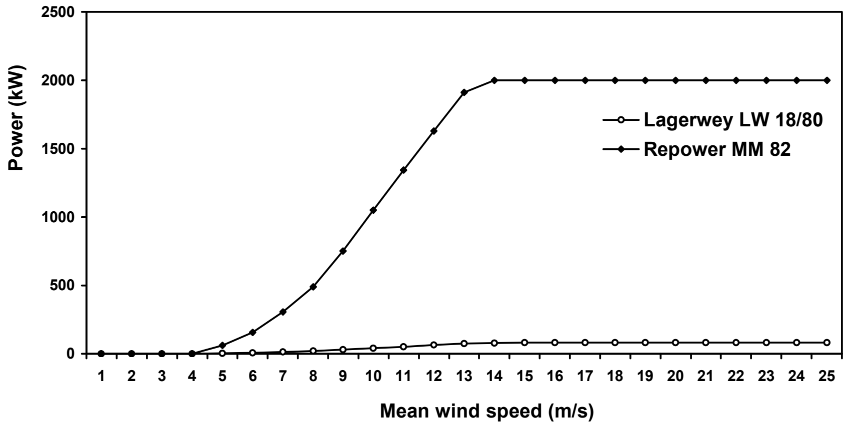

Fig. 4. The power curve for the two chosen wind turbines.

Table 4

Characteristics of the selected wind turbines

Characteristics	Turbine (1)	Turbine (2)
Turbine model	*Lagerwey LW 18/80*	*Repower MM82*
Rated Power (P_r) (kW)	80	2000
Hub height (m)	40	100
Rotor diameter (m)	18	82
Swept area (m^2)	254	5281
Number of blades	2	3
Cut-in wind speed (V_{ci}) (m/s)	3	4
Rated wind speed (V_r) (m/s)	14	13
Cut-off wind speed (V_{co}) (m/s)	25	25
Price / Euro	97,145	1,850,000

5.1. Estimation of the energy output from the single *Repower MM82* turbine

By Eq. (3) we find the annual wind speed at the hub height of this turbine. For Sidi Barrani, Mersa Matruh and El Dabaa it will be: 8.89, 9.42 and 9.60 m/s, respectively, at the 100 m height. Given the power curve of the *Repower MM82* turbine, the WASP program was used to estimate the actual yearly energy production at the three stations [17–19]. The yearly energy output, E_{out} (kWh/year), for these stations is summarized in Table 5. The annual energy production was found to be 7118.2, 7765.5 and 7975.3 MWh/year, respectively.

Table 5

The annual energy production from the two different systems at the selected sites

Station	E_{out} (kWh/year)	
	Wind farm (2 MW) / H = 40 m	Single machine (2 MW) / H = 100 m
	Lagerwey LW 18/80	*Repower MM82*
Sidi Barrani	4,726,226.3	7,118,226.2
Mersa Matruh	5,318,903.6	7,765,541.5
El Dabaa	5,510,702.2	7,975.302.9

5.2. Estimation of the energy output from the 2 MW wind farm

The wind farm to be installed at the three sites consists of 25 wind turbines (the power curve is given in Fig. 4). For Sidi Barrani, Mersa Matruh and El Dabaa, the annual mean wind speed is calculated to be: 7.07, 7.50 and 7.64 m/s, respectively, at a 40 m height. This is done using Eq. (3) for the hub height of the *Lagerwey LW 18/80* turbine. Using these data along with WASP program, the annual energy production was found to be 472.6, 531.8 and 551.0 MWh/year for the three stations, respectively (see Table 5).

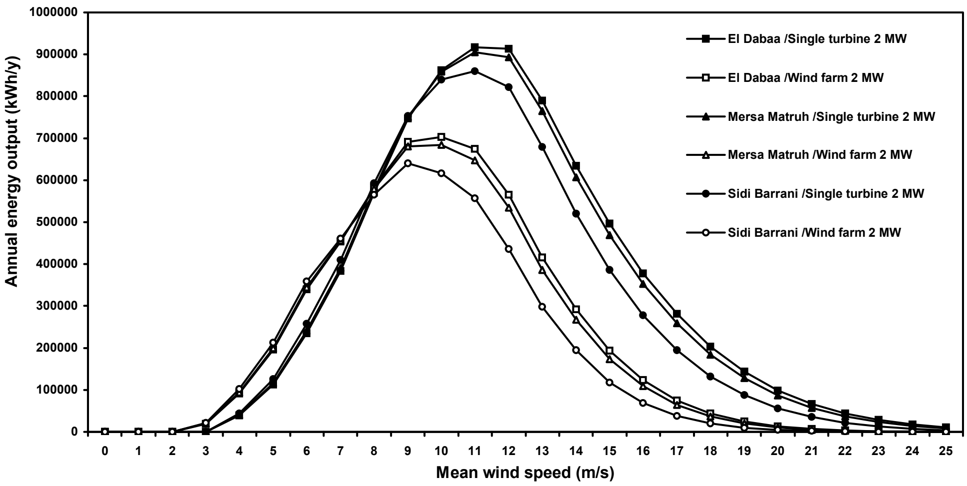

Fig. 5. Annual energy output from the two different WEC systems: single turbine 2 MW and wind farm of 2 MW total power, as function of mean wind speed at three stations in Egypt.

Figure 5 shows the relation between the yearly energy output as a function of the mean wind speed for the two cases (single turbine and wind farm) at the three sites. From this figure, the following can be deduced:

1. The maximum yearly energy is derived from winds with speed 11 m/s in the case of a single 2 MW wind turbine, and with speed 10 m/s in the case of the wind farm. The maximum annual energy (at all stations) is obtained for wind speeds between 4 to 24 m/s for the single 2 MW turbine and from 4 to 18 m/s for the wind farm.
2. In the case of a single 2 MW turbine, the accumulated annual wind energy at the considered stations ranges from 839 MWh (at the Sidi Barrani station) to

the maximum of 917 MWh (at the El Dabaa station) per year. However in the case of the wind farm, the range is from 639 MWh/year to 703 MWh/year for the Sidi Barrani and El Dabaa stations, respectively.

3. Very low wind energy is derived below a wind speed of 3 m/s in the two cases.
4. The single 2 MW wind turbine at the three stations can produce more energy per year than the 2 MW wind farm. The maximum yearly energy gain from the wind turbines for the two cases is found to be 5510 MWh/year and 7975 MWh/year at the El Dabaa station (Table 5).

6. ECONOMIC AND COST ANALYSIS

To estimate the cost of a kWh produced by the chosen wind energy conversion systems (WECS), the method of the present value of money is employed. In order to calculate the present value of costs (PVC) of the electricity produced per year, the following expression proposed by Lysen [20] and referred by Rehman *et al*. [21] was used in our study:

$$\text{PVC} = \mathbf{I} + \mathbf{C}_{omr}\left[\frac{\mathbf{1}+\mathbf{i}}{\mathbf{r}-\mathbf{i}}\right]\times\left[1-\left(\frac{\mathbf{1}+\mathbf{i}}{\mathbf{1}+\mathbf{r}}\right)^{\mathbf{t}}\right]-\mathbf{S}\left(\frac{\mathbf{1}+\mathbf{i}}{\mathbf{1}+\mathbf{r}}\right)^{\mathbf{t}}. \quad (5)$$

In this equation:

I is the investment cost of the wind machine, which includes the turbine price plus 20% for the civil works and connection cables to the gird;

$\mathbf{C}_{omr}$ is the operation maintenance and repair cost, which is 25% of the annual cost of the turbine (machine price/life time);

r is the discount rate (15%), and **i** is the inflation rate (12%);

S is the scrap value (10% of the turbine price and civil work);

t is the lifetime of the machine, which is assumed to be 20 years.

Table 6

The expected cost of kWh of electricity generated using two different WEC systems at the three stations

Station	Cost (€ cent/kWh)*	
	Wind farm (2 MW)	Single machine (2 MW)
Sidi Barrani	3.4	1.7
Mersa Matruh	3.0	1.6
El Dabaa	2.9	1.5

* 1 Euro = 100 cent and 1 Euro ≈ 7.5 Egyptian pounds; 1 Pound = 100 Piaster.

The price of the wind turbine and civil works for each of the investigated systems were substituted into Eq. (5), and in the case of the wind farm the capital investment, **I,** is taken as the number of units multiplied by the unit price, from which the PVC for each system was obtained [22]. Dividing this value by the total energy produced during the life time of the machines of each system, the PVC for 1 kWh was obtained for each system at each of the three sites. The results are given in Table 6.

From this table we can derive that:

1. In the case of a single 2 MW wind turbine, the cost of 1 kWh electricity produced varies between (1.5–1.7) € cent/kWh. At the same time, in the case of the wind farm, the cost of electricity production was found to be (2.9–3.4) € cent/kWh (1 EURO ≈ 7.5 Egyptian pounds). Hence, the single 2 MW wind turbine is more efficient than the wind farm.
2. These results are in line with the information in [1], whose authors concluded that the expected cost of electricity generation was to be 2 € cent/kWh at the El Dabaa station, where another 1000 kW wind turbine (AN Bonus 1MW/54) was used. Also, these results agree with El-Kordy *et al*. [8], who concluded that WEC systems have the lowest cost in Egypt (1.8085 $ cent/kWh, see Table 7).
3. Comparing the expected cost of electricity generation by a single 2 MW wind turbine at Sidi Barrani, Mersa Matruh and El Dabaa stations with the cost of 1 kWh produced by the Egyptian Electricity Authority using diesel oil, natural gas and photovoltaic systems, one can see that the former is highly competitive taking into account the actual tariff system in Egypt (see Table 7).

Table 7

The cost of kWh of electricity generated from different systems actually used in Egypt [20]

System	Cost ($ cent/kWh)
1. WEC system	1.8085
2. Combined cycle system	2.3555
3. Conventional steam-fuel oil fired system	5.4256
4. Diesel oil fired gas turbine	5.4266
5. Photovoltaic system	13.9612

7. CONCLUSIONS

In this study, we have found that:

1. The prevailing wind direction is north-west during the year at the three sites: Sidi Barrani, Mersa Matruh and El Dabaa (see Table 1).
2. At these contiguous stations along the western cost of Mediterranean Sea in Egypt the power density is as high as in Denmark (the inland potential close to Vindeby) and is similar to the power density in European countries: from 340 to 425 W/m^2 at the height of 70 m and 450 to 555 W/m^2 at the height of 100 m.
3. The use of a single 2 MW wind turbine at the three sites will give more energy per year than the wind farm with the total power of 2 MW. The maximum yearly energy gain from the wind turbines in the two cases is 5510 MWh/year and 7975 MWh/year at El Dabaa station.
4. The single 2MW wind turbine is more effective than the wind farm. For all the three stations the electricity production cost was found to be less than 2 € cent/kWh, which is about half the specific cost of the wind farm.

5. The results of this study would encourage the construction of large wind turbines with a power level of 2000 kW at the three stations, where the expected cost of electricity generation by a single 2 MW wind turbine was found to be very competitive with the cost of kW hours produced by the Egyptian Electricity Authority using diesel oil, natural gas and photovoltaic systems as shown by the actual tariff system in Egypt (see Table 7).

REFERENCES

1. Shata, A.S.A., & Hanitsch, R. (2006). Evaluation of wind energy potential and electricity generation on the coast of Mediterranean Sea in Egypt. *Renewable Energy*, *31*, 1183–1202.
2. Salem, A.I., Abdelaty, S.A., Abu El-Eizz, H.M., & Shata, A. (1999). Wind Energy Potential over Egypt. *The 4th Conf. of Meteorology and Sustainable Development to 21st Century*, Cairo (Egypt), 148–162.
3. Salem, A.I. (1995). Characteristics of surface wind speed and direction over Egypt. *Solar Energy for Sustainable Development* (Romania), *4* (2), 56–63.
4. Abdelaty, S.M. (2006). Wind and Solar Power Availability in Some Coastal Sites of Egypt. *Academic Open Internet Journal*, *17*.
5. Al-Motawakel, M.K., Abu El-Eizz, H.M., & Awwad, Z. (1991). Performance of different types of renewable power supply systems. *International Journal of Ambient Energy*, *12* (4), 205–213.
6. Ahmed, S.A.S., & Hanitsch, R. (2006). The potential of electricity generation on the east coast of Red Sea in Egypt. *Renewable Energy*, *31*, 1597–1615.
7. Mortensen, N.G., & Usama, S.S. (1996). Wind Atlas for the Gulf of Suez, Arab Republic of Egypt. Measurements and modeling 1991-1995. *European Wind Energy Conference*, Sweden Göteborg (Sweden): H. S. Stephens & Associates Ltd, p.623–626.
8. El-Kordy, M.N., Bader, M.A., Abed, K.A., & Said, I.M.A. (2002). Economical evaluation of electricity generation considering externalities. *Renewable Energy*, *25*, 317–328.
9. Isaac, Y.F., Joseph, L., and Lam, C. (2000), “A study of Weibull parameters using long-term wind observations”, *Renewable Energy*, *20*, 145–153.
10. Chinnasamy, T.V., & Haridasan, T.M. (1991). Wind energy potential at Palkalainagar. *Renewable Energy*, *1* (5/6), 815–821
11. A-Hamid, M., & Hamdy, A.A. (2003). Economics of off-shore/on-shore wind energy systems in Qatar. *Renewable Energy*, *28*, 1953–1963.
12. Chi-ming, L., & Ta-hui, L. (2006). Technical assessment of the use of a small-scale wind power system to meet the demand for electricity in a land aquafarm in Taiwan. *Renewable Energy*, *31*, 877–892.
13. Khogali, A., Albar, O.F., & Yousif, B. (1991). Wind and solar energy potential in Makkah (Saudi Arabia) ‑ comparison with Red Sea coastal sites. *Renewable Energy*, *1*(3), 435–40.
14. Norbert, A., Joseph, M.D., & Epiphane, A. (1991). Estimation of mean wind energy available in Benin (Ex Dahomey). *Renewable Energy*, *1*(5/6), 845–853.
15. Justus, C.G., & Mikhail, A. (1976). Height variation of wind speed and wind distributions statistics. *Geophysical Research Letters*, *3*(5), 261–264.
16. Al-Nasser, W., Alhajraf, S., Al-Enizi, A., & Al-Awadhi, L. (2005). Potential wind power generation in the State of Kuwait. *Renewable Energy*, *30*, 2149–2161.
17. Naif, M., & Al-Abbadi. (2005). Wind energy resource assessment for five locations in Saudi Arabia. *Renewable Energy*, *30*, 1489–1499.

18. Ozerdem, B., & Turkeli, H.M. (2005). Wind energy potential estimation and micro-sitting on Izmir Institute of Technology Campus, Turkey. *Renewable Energy*, *30*, 1623–1633.
19. Bilgili, M., Sahin, B., & Kahraman, A. (2004). Wind energy potential in Antakya and Iskenderun regions, Turkey. *Renewable Energy*, *29*, 1733–1745.
20. Lysen, H. (1983). Introduction to Wind Energy. *Consultancy Services, Wind Energy, Developing Countries* (CWD), 82-1, 2nd Ed-n, Netherlands, p.36-47
21. Rehman, S., Halawani, T.O., & Mohandes, M. (2003). Wind power cost assessment at twenty locations in the kingdom of Saudi Arabia. *Renewable Energy*, *28*, 573–583.
22. Habali, S.M., Hamdan, A.S., Jubran, B.A., & Adnan, I.O.Z. (1988). Assessment and applications of wind energy in Jordan. *Solar Energy*, *40*(2), 99–105.

ELEKTROENERĢIJAS RAŽOŠANAS POTENCIĀLS VIDUSJŪRAS RIETUMA KRASTĀ, ĒĢIPTĒ

A.S. Ahmed Shata, S.M. Abdelaty and R. Hanitsch

Kopsavilkums

Tika veikta tehniski ekonomiskā analīze, lai novērtētu vēja ģeneratorus, kuri uzstādīti trijos daudzsološos no vēja enerģijas viedokļa reģionos: Sidi Barrani, Mersa Matruh un El Dabaa Vidusjūras rietumu krastā, Ēģiptē, iespējamo elektroenerģijas izstrādi.

Šīs stacijas raksturojas ar vēja vidējiem gada ātrumiem lielākiem par 5.0 m/s 10 m augstumā. Bija izrēķināti Weibulla parametri un pakāpes sakarības koeficients un tos izmantoja, lai aprakstītu sezonu vēju sadali un uzvedību uz šīm stacijām.

Dati par gada vēja potenciālu 70–100 m augstumā tika iegūti uz rezultāta datu pamata 10 m augstumā no iepriekšējiem darbiem ar ekstrapolāciju, izmantojot pakāpes sakarību. Trīs stacijas raksturojas ar augstu vēja enerģijas blīvumu diapazonā no 340–425 līdz 450–555 W/m^2 atbilstoši 70–100 m augstumā. Darbā veikta elektroenerģijas, kura tika saražota, izmantojot divas dažādas sistēmas; vienas kWh izmaksu analīze: viena sistēma – izmantojot salīdzinoši lielu 2 MW vēja turbīnu un otra – 25 nelielas vēja turbīnas ar jaudu 80 kW (kopā 2 MW) , kas apvienotās vēja parkā.

Tika noteikta katras sistēmas gada enerģijas izstrāde un elektroenerģijas ražošanas izmaksas katrā gadījumā, tika arī aprēķinātas un salīdzinātas ar elektroenerģijas ražošanas izmaksām, izmatojot dīzeļdegvielu, dabas gāzi un saules PV baterijas sistēmas, kuras sagādāja Ēģiptes Elektroenerģijas Pārvalde.

Aprēķini parādīja, ka 2 MW vēja turbīna strādā daudz efektīvāk nekā vēja parks un ka visu trīs staciju elektroenerģijas ražošanas izmaksas ir zemākas par 2 € cents/kWh, kas ir puse no raksturīgām vēja parku izmaksām.

15.04.2008.