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Sustainable Development in Iranian South coastal and Islands Using Wind Energy

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***Abstract*—**The development incompatible with environment cannot be sustainable. Using renewable energy sources such as solar energy, geothermal energy and wind energy can make sustainable development in a region.

Iran has a lot of renewable and nonrenewable energy resources. Since Iran has a special geographic position, it has lot of solar and wind energy resources. Both solar and wind energy are free, renewable and adaptable with environment.

The study of 10 year wind data in Iranian South coastal and Islands synoptic stations shows that the production of wind power electricity and water pumping is possible in this region.

In this research, we studied the local and temporal distribution of wind using three – hour statistics of windspeed in Iranian South coastal and Islands synoptic stations. This research shows that the production of wind power electricity is possible in this region all the year.

Keywords—Wind energy, Wind regime, Wind electricity, Synoptic station

I. Introduction

In Iran, utilizing the wind energy for generating the wind electricity at Manjil and Binalood zone has been started. Some projects are also being constructed in Qazvin, Zanjan, Gilan and Khorasan Razavi but no enough attention has been paid to utilize the wind energy of coastal waters and to construct the wind farms on the coasts and coastal waters. [1] In order to have stable energy resources and compatible with the environment, it`s necessary to take this issue into consideration and to study the possibility of application this energy.

In this surrey, it has been tried to identify the conditions of the wind energy with local and time distributions on Persian Gulf islands and coasts and suitable times and locations to utilize the wind energy on Persian Gulf islands and coasts.

The usage of the wind energy has a long history. The first wind machines were used at the 7th century B.C in high parts of Afghanistan to grind the corns.

The first signs of wind machines have been found in Iran, Tibet and China around 1000 years ago. Wind machines found their ways to the neighboring countries of Mediterranean Sea and central Europe from Iran and Middle East. The first wind machines were appeared in England around the year 1150, France 1180, Fin 1190, Germany 1222 and Denmark 1259 A.D. This rapid development was due to the Crusades caused the transfer of the wind machines knowledge from Iran to Europe [2]

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On the Zones with frequent winds and speed over 8 knots, wind turbines may be used to a variety of applications. Studying the condition of the wind at Iran synoptic stations during the years 1981-1985 revealed that Zabol station (Sistan zone) has the best condition for constructing the wind farms in the whole country [3].

Regarding the condition of the wind blowing in Sistan and using the daily maps of the earth surface and the level of 850 H.P, Hosseinzadeh concluded that winds directions at the level of 850 H.P has no relationship with the earth surface and Systan wind is one of the phenomena of the earth surface that its initial cause is the placement of a relatively strong low-pressure center in the southeast of Iran and two high-pressure centers over the Caspian sea and the northeast heights out of the country. Of course, the northern and northeast heights of Iran are regarded as additional factors in intensification of these winds [4].

Gandomkar studied the potential of the wind energy in Iran through a surrey titled "the evaluation of the wind energy potential on the windy zones" in 2006 and concluded that Sistan zone and some scattered areas in the country such as Manjil, Aligoodarz, Ardebil and so on have the best conditions for utilizing the wind energy. [5]

Gandomkar studied the possibility of the wind energy utilization in Isfahan in 2006 and concluded that in this province, Ardestan zone has a high capacity to use the wind energy for pumping the agricultural water and generating the windy electricity. [6]

Frandsen and etal [7] shows that The proposed model for the wind speed deficit in wind farms is analytical and encompasses both small wind farms and wind farms extending over large areas. As is often the need for offshore wind farms, the model handles regular array geometry with straight rows of wind turbines and equidistant spacing between units in each row and equidistant spacing between rows. Firstly, the case with the flow direction being parallel to rows in a rectangular geometry is considered by defining three flow regimes. Secondly, when the flow is not in line with the main rows, solutions are suggested for the patterns of wind turbine units corresponding to each wind direction. The presentation is an outline of a model complex that will be adjusted and calibrated with measurements in the near future.

Borlando and etal [8] by The analysis is based on a 3-year long time-series of measurements of the wind velocity from 11 anemometric stations located along the perimeter of the island. Since the present study was an analysis preliminary to the subsequent assessment of the wind potential of Corsica, we have worked only with wind intensities. Nevertheless, at the end of our analysis, we have also considered wind directions for the final interpretation of the results. The anemological regions are defined through the comparison of 15 different clustering techniques resulting from the combination of three distance measures and five agglomerative methods. As confirmed by geographical considerations, the results identify three distinct anemological regions: the eastern region (ER), the north-western region (NWR), the south-western region (SWR). The wind regimes are identified by means of a two-stage classification scheme based on a hierarchical cluster analysis followed by a partitional clustering. The final classification identifies eight regimes: the four wind regimes corresponding to the main weather patterns of Western Europe, as proposed by Plaut and Simonnet, and another four clusters corresponding to breeze regimes.

Reikard [9] shows that The regime-switching model uses a persistence forecast during periods of high wind speed, and regressions for low and intermediate speeds. These techniques are tested on three databases. Two main criteria are used to evaluate the outcomes, the number of high and low states than can be predicted correctly and the mean absolute percent error of the forecast. Neural nets are found to predict the state transitions somewhat better than logistic regressions, although the regressions do not do badly. Three methods all achieve about the same degree of forecast accuracy: multivariate regressions, state transition and regime-switching models. If the states could be predicted perfectly, the regime-switching model would improve forecast accuracy by an additional 2.5 to 3 percentage points. Analysis of the density functions of wind speed and the forecasting models finds that the regime-switching method more closely approximates the distribution of the actual data.

Elizano and etal [10] shows that In the case of the rapidly spinning load configurations, a finite power production at wind speeds below the theoretical cut-in speed can be observed, which can be explained in terms of inertia effects. During the measurement campaigns with high loads, we were able to observe bifurcations of the power curve, which can be explained in terms of instabilities arising in situations of transition from attached to separated flow. A full experimental Cp (λ)-curve has been constructed by operating the turbine under different load conditions and the findings are in good agreement with a variable Reynolds-number blade-element momentum model. The three proposed system configurations have been found to operate with a high aerodynamic efficiency with typical values of the power coefficient in the 0.40–0.45 range.

II. Methodology

To study the wind condition over the southern islands and coasts of Iran, a three-hour-statistic of the wind direction and speed at Synoptic stations (Meteorology department) in the southern islands and coasts of Iran were used due to having complete statistics. Initially, the statistic of the wind direction and speed with a three-hour-frequency (hours 00,03,06,09,12,15,18 and 24 based on Greenwich Time) at 15 stations of the zone were studied. Regarding the required time periods (10 years from January first 1996 to December 2005) ten stations had complete statistics for the whole period or a complete 10-year-statistic at special times of the day were selected. Totally, each station has 26217 data related to the wind direction at 3-hour-intervals.

Firstly, the mean of the wind speed was calculated for each 3-hour-periods and then the mean of the wind speed and the maximum of the wind blowing speed and the incidence percent of winds with the speed less than eight knots and above it were calculated (a suitable speed for using the wind energy to generate the wind electricity is about eight knots or $4\,{}^{m}\!/\!{}_{s}$). A summary of results is given in table 1.

To prepare the maps of the wind blowing scattering, surfer software was used and with respect to the wind speed and direction, required maps were drawn. When drawing the maps, the statistics related to the stations location were only used. It`s because the wind blowing speed is both dependent upon the condition of planet public systems and the local conditions. For example, the windiest point in Iran is Manjil but when moving toward the north and entering the margin zone of the Caspian and in a short distance of Manjil, we arrive in one of the mildest zones of the country for the speed of the wind blowing.

Therefore, to design the maps of windy zones, the station statistic was only used and in respect to the speed of the wind blowing, the places had a high speed of eight knots were determined as a windy places with a capacity of utilization the wind energy.

To study the wind blowing speed distribution as well as wind blowing direction scattering, SPSS software was used. By introducing each of the speed measures and the wind blowing direction in this software, the quality of the wind blowing speed and direction were identified and the original directions of the wind blowing as well as the percent of the weak and strong winds determined.

Daily statistics of rainfall in synoptic station has been used to specify torrential rain in Isfahan. So by analysis the amount to rain from January 1th in 1951 until the end of December in 2005 the heaviest rainfall has been reported from this station.

Data of sea level pressure and geo potential height of different levels were used to investigate the atmospheric systems that cause torrential rain. The following data of 500th, 700th and 850th layer have been investigated daily dimensions of these data from January 1th in 1951 until the end of December in 2005, Were 2.5 degree by 2.5 degree and 0o to 90o Northern latitude and 0o to 150o Eastern longitude. To this end daily maps of each stratum have been drawn (for each stratum 16436 maps) these data have been collated from atmosphere organization and oceanographic organization of united state.

TABLE I
SUMMARY OF SYNOPTIC STATION WIND STATISTIC IN IRANIAN SOUTH COASTAL AND ISLANDS

Station	Longitude (Degree)	Latitude (Degree)	Elevation (Meter)	Mean wind speed (Knot)	Maximum wind speed (Knot)	Percent less than 8 knots of wind speed	Percent higher than 8 knots of wind speed
Abadan	48.25	30.37	6.6	5.7	37	61	39
Abumoosa	54.83	25.83	6.6	6.78	39	52.6	47.4
Bandarabbas	56.37	27.22	10	5.48	33	66.8	32.2
Bandarlenge	54.38	26.58	14.2	5.7	35	68.3	31.7
Mahshahr	49.15	30.55	6.2	7.32	39	50.2	49.8
Bushehe	50.83	28.98	19.6	5.28	29	63.5	36.5
Chabahar	60.62	25.28	8	7.13	31	48.6	51.4
Jask	57.77	25.63	4.8	7.87	58	46.9	53.1
Kish	53.98	26.5	30	8.75	47	45.7	54.3
Siri	54.48	25.88	4.4	7.8	31	44.9	55.1
Mean	- -	- -	- -	6.76	37.9	54.85	46.15
Maximum	- -	- -	- -	8.57	58	68.3	55.1
Minimum	- -	- -	- -	5.28	29	44.9	31.7

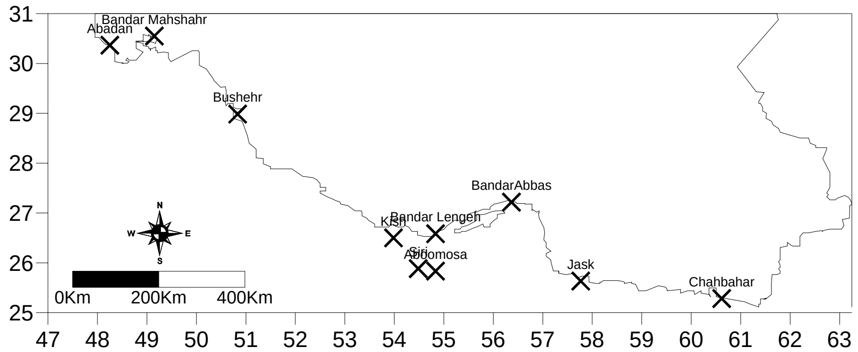

Fig. 1 Distribution of Synoptic station in Iranian South Coastal and Islands

III. DISCUSSION

Based on the annual average of the wind speed at the stations of Iran`s southern islands and coasts, Kish island station with an annual average of 8.57 knots has the highest average of the wind blowing speed. After that, Mahshahr, Chabahar and Jask and Siri island stations have an annual average of more than seven knots. The annual average of the wind blowing speed at Abumoosa island station is also higher than six knots and at Abadan, Bandarabbas, Bandarlengeh and Bushehr stations it`s more than fire knots (Fig.2).

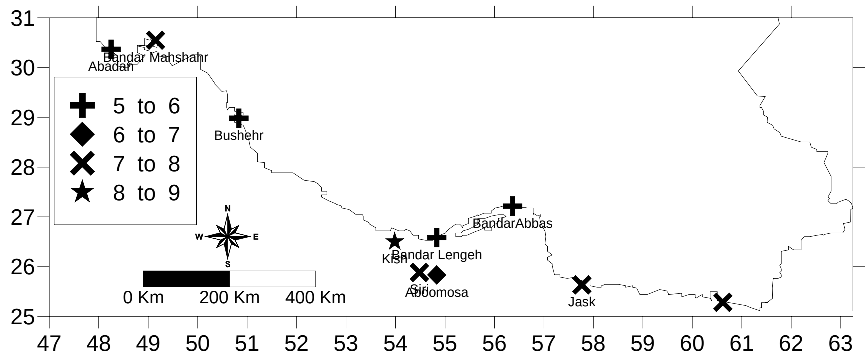

Fig. 2 Annual mean wind speed (Knot)

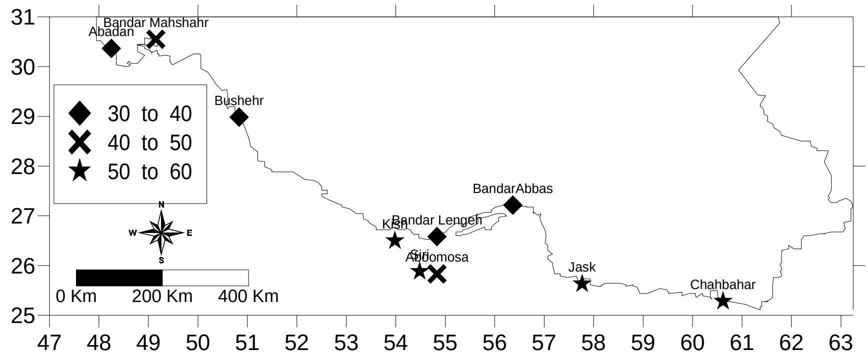

Fig. 3 Percent higher than 8 knots of wind speed

Fig.3 shows the percent of the winds with a speed higher than eight knots at the stations of this zone. According to this map, Siri island station is with a wind speed higher than eight knots at about %55 times of the year and for this reason has gained the first order to itself. Next, Kish, Jask and Chabahar stations are with wind speeds higher than eight knots more than %50 of the times.Bandarlengeh station is with a wind speed higher than eight knots at about %31.7 of the times in a year and from this view locates at the order of this zone.

In general, according to the annual mean of the wind speed and the recorded cases percent of the wind speed higher than eight knots, Kish, Siri, Jask, Chabahar, Bandar Mahshahr and Abumoosa stations may be considered as the windy stations of the country so they are very suitable for generating electrical energy using the wind energy. (1 in Fig. 4)

Abadan, Bushehr and Bandarabbas stations are windy in some of the months or some times of the days and nights so they`re also suitable for generating the wind electrical energy. (2 in Fig. 4)

Bandarlengeh station has a high wind speed at short times of the year so it may be suitable for generating the windy electricity with a small amount and using the wind energy for pumping the water. (3 in Fig. 4)

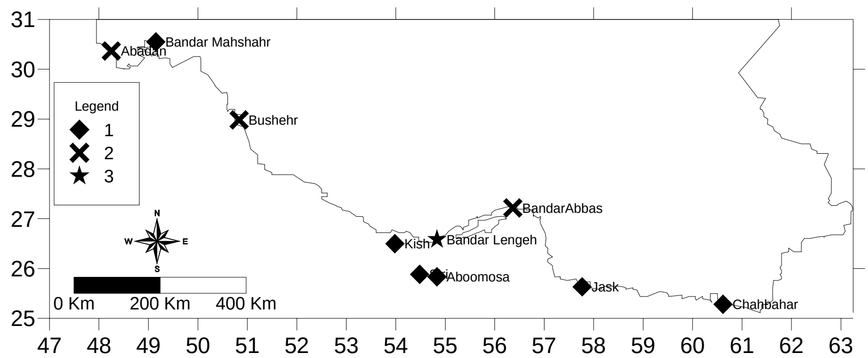

Fig. 4 Station classification for using wind energy

TABLE II
WIND ENERGY LOCAL DISTRIBUTIONS IN IRANIAN SOUTH COASTAL AND ISLANDS

Station	Windy month	Windy time (Hour in Iran)	Angle of the fast winds	Direction of the fast winds
Kish	All month	18	300	Northwest
Siri Island	From January to May and November to December	18	270 to 290	West
Jask	February, March, August, September	12	310 150	Northwest Southeast
Chabahar	From February to April and June to August	15	150	Southeast
Mahshahr	From April to August	15	300	Northwest
Abumoosa	February, March, April, November	18	270	West
Abadan	From May to September	18	300	Northwest
Bushehr	From February to September	12	300	Northwest
Bandarabbas	From April to October	18	190	West
Bandarlenge	April	--	210	Northeast

Studying the time scattering of the wind energy on the southern islands and coasts of Iran shows that at this zone, April is the windiest month of the year.From the total ten stations present at this zone, eight stations have the wind capacity and the wind energy may be applied to generate the windy electricity. After April, August with seven windy stations has the highest potential of generation the windy electricity. February, March, May, June and July have six windy stations. In September, five stations are windy and in November three stations have the windy potential. Finally, January, October and December are in order only having two windy stations. From the view of seasonal distribution, spring is the mildest season for blowing the wind at this zone.

TABLE III
WIND ENERGY TEMPORAL DISTRIBUTIONS IN IRANIAN SOUTH COASTAL AND ISLANDS

Number	Month	Windy Stations	Number of Windy Stations
1	January	Kish, Siri	2
2	February	Kish, Siri, Abumoosa, Jask, Chabahar, Bushehr	6
3	March	Kish, Siri, Abumoosa, Jask, Chabahar, Bushehr	6
4	April	Kish, Siri, Abumoosa, Chabahar, Bushehr, Bandarabbas, Bandarlenge, Mahshahr	8
5	May	Kish, Siri, Bushehr, Bandarabbas, Mahshahr, Abadan	6
6	June	Kish, Chabahar, Bushehr, Bandarabbas, Mahshahr, Abadan	6
7	July	Kish, Chabahar, Bushehr, Bandarabbas, Mahshahr, Abadan	6
8	August	Kish, Chabahar, Bushehr, Bandarabbas, Mahshahr, Abadan, Jask	7
9	September	Kish, Bushehr, Bandarabbas, Abadan, Jask	5
10	October	Kish, Bandarabbas	2
11	November	Kish, Siri, Abumoosa	3
12	December	Kish, Siri	2

TABLE IV
WIND ENERGY TEMPORAL AND LOCAL DISTRIBUTIONS IN IRANIAN SOUTH COASTAL AND ISLANDS

Station / Month	Kish	Siri	Abumoosa	Chabahar	Jask	Bandarabbas	Bushehr	Mahshahr	Abadan	Bandarlenge
January	Suitable	Suitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
February	Suitable	Suitable	Suitable	Suitable	Suitable	Unsuitable	Suitable	Unsuitable	Unsuitable	Unsuitable
March	Suitable	Suitable	Suitable	Suitable	Suitable	Unsuitable	Suitable	Unsuitable	Unsuitable	Unsuitable
April	Suitable	Suitable	Suitable	Suitable	Unsuitable	Suitable	Suitable	Suitable	Unsuitable	Suitable
May	Suitable	Suitable	Unsuitable	Unsuitable	Unsuitable	Suitable	Suitable	Suitable	Suitable	Unsuitable
June	Suitable	Unsuitable	Unsuitable	Suitable	Unsuitable	Suitable	Suitable	Suitable	Suitable	Unsuitable
July	Suitable	Unsuitable	Unsuitable	Suitable	Unsuitable	Suitable	Suitable	Suitable	Suitable	Unsuitable
August	Suitable	Unsuitable	Unsuitable	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable	Unsuitable
September	Suitable	Unsuitable	Unsuitable	Unsuitable	Suitable	Suitable	Suitable	Unsuitable	Suitable	Unsuitable
October	Suitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Suitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
November	Suitable	Suitable	Suitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
December	Suitable	Suitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable

IV. CONCLUSION

Studying the wind condition on the southern islands and coasts of Iran based on a 3-hour-statistic and the wind speed at synoptic stations of the country in the southern islands and coasts had a complete statistic showed that there is a potential of utilization the wind energy in this zone.

Based on the statistic analysis of the wind direction and speed and the recorded percent of the wind speed higher than eight knots, Kish, Siri, Jask, Mahshahr and Abumoosa stations may be considered as the windy stations very suitable for applying the wind energy for generating the electrical energy.

Abadan, Bushehr and Bandarabbas stations are windy in some of the months of the year or some times of the days and nights, so they are suitable for generating the windy electrical energy.

Bandarlengeh station has a high wind speed at short times of the year, so it`s suitable for generating the windy electricity with small amounts and utilizing the wind energy for pumping the water.

Generally, the southern islands and coasts of Iran onto and margins of the Persian Gulf and Oman Sea are windy until the middle of September (middle winter to the late summer) and in the months of the spring (March, April and May) more of the stations in this zone are windy with a potential of generation the windy electrical energy. Since, these months are the onset of the heat season and much electrical energy usage, it`s very necessary to use a free and clear energy for generating the windy electrical energy.

From the view of the time scattering, April is the windiest season of the year and wholly out of ten stations present at this zone, eight have the windy potential and the wind energy may be utilized to generate the windy electricity.

After April, August with seven windy stations has the highest potential for generating the windy electricity. February, March, May, June and July have six windy stations. In September, there are five windy stations and in November three stations have the windy potential. January, October and December are at the final order with only two windy stations. From the view of seasonal distribution, spring is the windiest season at this zone and then there is the summer and winter and the fall is also the mildest season for blowing the wind at this zone.

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