Abadeh	5	2.016	0.867
Fasa	4	1.613	0.801
Kazerun	4	1.613	0.801
Shiraz	4	1.613	0.801

According to statistics related to earthquakes, the number of recorded earthquakes in different cities of Fars province belongs to a 100 year period. In this case, there was no record of destructive earthquakes that can damage wind turbines (8 and higher on the Richter scale (www.SUNA.org.ir) in any of these areas, so the probability of destructive earthquake was considered zero for all these cities.

The number of events related to dust storms category is high, so Poisson distribution cannot be used. In this case, given the high number of trials (number of studied days) we used Binomial distribution with normal approximation. This approximation involves calculating the probability of success (***p***) and the number of trials (***n***) for Binomial distribution, and then calculating the mean (μ) and standard deviation (σ) of normal distribution by equations 9 and 10 and ultimately calculating the probability of at least 1 event by normal distribution.

$$(9)\mu = np$$

$$(10)\sigma^2 = np(1-p)$$

In here, ***n*** is the number of days which means the number of days in normal lifespan of a turbine (25 years), so it is 9131 days. Then the probability of at least one dust storm in a period of 25 years must be calculated. Table 6 shows the statistics of this event for each city and calculations of variables ***p*** (the probability of dust storm in a day in Binomial distribution), and ***n*** (the number of studied days or number of trials in Binomial distribution), normal μ and σ and ultimately the probability of at least 1 such event.

Table 6. Binomial distribution parameters and probability of dust storm occurrence.

City	p	n=9131 (25×365+6)	μ=np	σ	Probability of at least once dust storm and normal distribution
Izadkhast	0.08	9131	750.49	26.245	0.86
Estahban	0.11	9131	1000.66	29.85	0.87
Safashahr	0.07	9131	675.44	25	0.86
Firuzabad	0.06	9131	525.35	22.25	0.86
Eghlid	0.14	9131	1250.82	32.85	0.88
Neyriz	0.15	9131	1325.87	33.66	0.88
Sepidan	0.03	9131	300.20	17.04	0.85
Arsanjan	0.003	9131	25.02	4.99	0.84
Bavanat	0.07	9131	625.41	24.14	0.86
Abadeh	0.11	9131	1000.66	29.85	0.87
Fasa	0.09	9131	825.54	27.4	0.86
Kazerun	0.06	9131	525.35	22.25	0.86
Shiraz	0.21	9131	1951.28	39.17	0.90

The final step is to combine the probabilities of these three natural disasters, so that we can obtain a value that can represent this criterion in the model. Thus, according to expert's opinion, weight coefficient of 0.25, 0.25, and 0.5 were considered for flood, earthquake and dust storm respectively, and results are presented in Table 7.

Table 7. Probability of once occurrence of natural disasters in 25 years.

City	Earthquake	Flood	Dust storm	Probability of natural disaster (at least one time in 25 years)
Izadkhast	0	0.816	0.86	0.647
Estahban	0	0.911	0.87	0.663
Safashahr	0	0.867	0.86	0.647
Firuzabad	0	0.941	0.86	0.665
Eghlid	0	0.867	0.88	0.657
Neyriz	0	0.911	0.88	0.668
Sepidan	0	0.911	0.85	0.653
Arsanjan	0	0.702	0.84	0.596

Bavanat	0	0.554	0.86	0.569
Abadeh	0	0.867	0.87	0.652
Fasa	0	0.801	0.86	0.630
Kazerun	0	0.801	0.86	0.630
Shiraz	0	0.801	0.90	0.650

4.6 Population

Another important criterion for the location of wind farm is population. It is obvious that this factor should be considered as an output of DEA model, because higher population means that area is more preferable for the installation of wind turbine. Table 8 shows the population of the cities.

Table 8. Population of the cities (Wikipedia.org).

City	Population (person)
Izadkhast	27800
Estahban	66172
Safashahr	50252
Firuzabad	119721
Eghlid	98188
Neyriz	113750
Sepidan	89398
Arsanjan	41476
Bavanat	48416
Abadeh	93975
Fasa	200000
Kazerun	320792
Shiraz	1700678

5. Discussion

AHP and FTOPSIS are applied to verify the results of DEA method. According to the results of three ranking methods, city of Izadkhast is the best option for the construction of wind farm, because it holds the top rank in validity assessment methods and second rank in DEA method. Therefore, changes in the ranking of Izadkhast are very low which shows the stability and reliability of its rank. Results of ranking by the MCDM approaches are shown in table 9.

Table 9. Results of the 3 ranking methods.

City	Ranking with DEA	Ranking with AHP	Ranking with FTOPSIS
Izadkhast	2	1	1
Estahban	5	6	5
Safashahr	8	2	4
Firuzabad	13	8	13
Eghlid	7	7	6
Neyriz	12	9	12
Sepidan	11	11	9
Arsanjan	10	4	3
Bavanat	3	3	2
Abadeh	9	10	8
Fasa	4	13	11
Kazerun	6	12	10
Shiraz	1	5	7

In this study, a rectifier with the efficiency of 95% and an electrolyzer with the energy consumption of 5 kWh/Nm3 were considered. Also, a coefficient for converting H_2-Nm^3 to H^2-ton should be considered in the analysis. A wind turbine of AWE 54-900 kW, manufactured by Americas Wind Energy Inc., is selected for the evaluations. The city

of Izadkhast was selected as the most appropriate location to generate wind energy. The best capacity factor of this wind turbine is related to the year of 2006 with the value of 18.9%.

6. Conclusion

The most important findings of this study can be summarized as follows:

- For ranking the cities, 6 important criteria including 3 output criteria of wind conditions, topographical conditions, and population and 3 input criteria of distance from distribution grid, land price, and probability of natural disasters were used for DEA model.
- The probability of 3 natural disasters of flood, earthquake, and dust storm were considered for this criterion as sub criteria, because they impose the risk of damaging or even destroying wind turbines. According to expert's opinion, weight coefficient of 0.25, 0.25, and 0.5 were considered for flood, earthquake and dust storm respectively
- For Bavanat and Neyriz were calculated the least (0.569) and the most (0.668) probability of natural disaster, respectively.
- Weibull distribution was used for calculation of wind power density. Finally specified that Izadkhast city has the most value of wind power between the other cities (with value of 166.64 W/m^2). Because wind power had given a "very important" preferential value in 2 validations method so Izadkhast were placed in top of the 13 cities with AHP and FTOPSIS.
- After ignoring places with trees, hills, mountains and tall building, Safashahr was specified as the best city in terms of topographic situation with 171 km^2 suitable lands, versus Shiraz was detected as the worst city with 117 km^2 suitable lands.
- Average of suitable distances to the city center in circle with 7.5 km radius for Neyriz was calculated 6.85 km so this city has most distance and versus Shiraz has least distance to distribution net.
- After executing DEA model, rank of 5 cities were specified but 8 cities including Izadkhast, Estahban, Safashahr, Eghlid, Bavanat, Fasa, Kazerun and Shiraz have obtained full efficiency score, so for ranking these cities is used from AP model.
- Final rank of the cities by usage of DEA was 1- Shiraz, 2- Izadkhast, 3- Bavanat, 4- Fasa, 5- Estahban, 6- Kazerun, 7- Eghlid, 8- Safashahr, 9- Abadeh, 10- Arsanjan, 11- Sepidan, 12- Neyriz and 13- Firuzabad.
- After ranking the cities with 2 validation methods, Izadkhast city was recommended to wind farm establishment.
- The utilizing a wind-hydrogen energy conversion system will result in a substantial amount of hydrogen production (averagely 21.9 ton/year) when a 900 kW wind turbine is installed in this location.

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