IOE 551 Final Project

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1 Introduction

Amidst global environmental concerns and the pressing need for sustainable development, the pursuit of clean energy solutions has become a paramount objective for nations worldwide. Iran, with its unique geographical and climatic diversity, stands at the crossroads of an energy transition, aiming to reduce its carbon footprint and diversify its energy sources. The deployment of wind power plants in Iran is especially crucial given the country's vast potential for wind energy, which remains largely untapped compared to traditional fossil fuels.

Figure 1: Wind Power Plant

Through Data Envelopment Analysis (DEA), this report will provide a sophisticated framework to support this transition. By evaluating the efficiency of potential locations for wind power plants across various Iranian cities—such as Tehran, Shiraz, Isfahan, and Tabriz, which incorporates multiple economic, environmental, and social factors. Choosing the optimal location for new wind power plant not only showcases the economic feasibility for implementing renewable energy projects in developing countries like Iran but also brings environmental benefits, such as reducing greenhouse gas emissions and local pollutants, which are crucial for enhancing public health and ecological resilience.

Furthermore, establishing wind power infrastructure in Iran serves multiple strategic interests: it reduces dependency on oil reserves, mitigates energy security risks, and promotes technological innovation and job creation in sustainable sectors. By using DEA to quantitatively assess and compare the potential of different locations within Iran, policymakers can make informed decisions that align with both national energy strategies and global sustainability goals. This methodical approach ensures that the chosen sites for wind power plants maximize energy production, minimize environmental impacts, and foster community acceptance and support, paving the way for a cleaner, more sustainable energy landscape in Iran.

2 Data Description and EDA

Decision Making Units(DMU)

Figure 2: Iran Cities

We focus on evaluating thirty-one distinct cities across Iran, which can be consider as Decision Making Units (DMUs) for our Data Envelopment Analysis (DEA). From major metropolitan area like Tehran and Shiraz to smaller towns such as Meymeh and Zarrineh, each city offers unique condition for consideration. Our main objective is to determine the most suitable city for constructing a wind power plant. The list of Iran cities we are going to analyze in this report are shown in the table below:

Abadan	Baft	Hamedan	Khodabandeh	Manjil	Shahrbabak	Tehran	Zabol
Ahvaz	Bandar Abbas	IIam	Khoram Abad	Meymeh	Shahre kord	Torbat-e-jam	Zahedan
Ardebil	Birjand	Karaj	Mahabad	Neyshabour	Shiraz	Urmia	Zarrineh
Ardestan	Boushehr	Kermanshah	Malayer	Sabzevar	Tabriz	Yazd	

Table 1: List of DMU

Variable

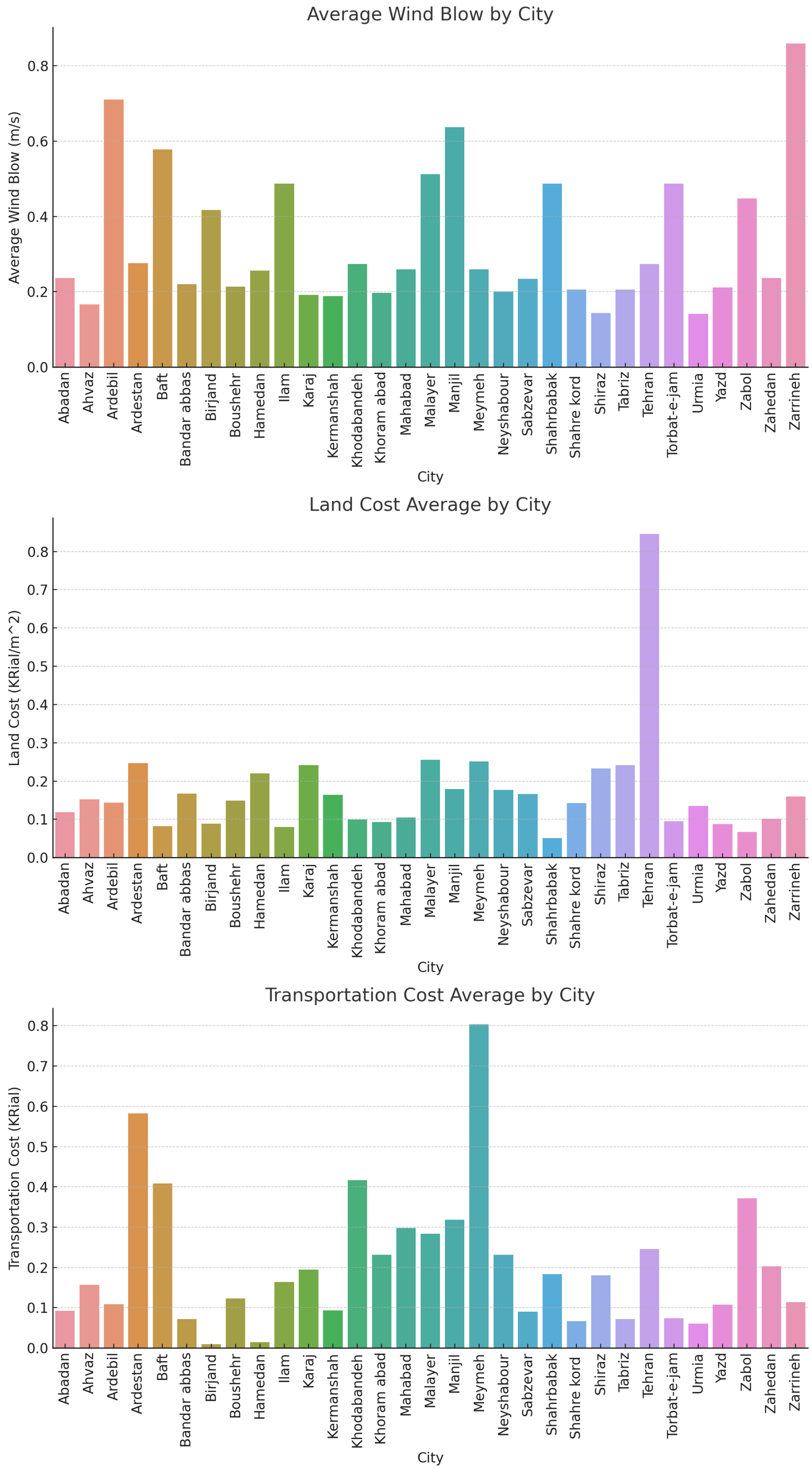

Figure 3: EDA - Factors versus Cities

- **Wind Speed**: Directly affects the potential energy output and efficiency of wind farms. Optimal locations with higher wind speeds can maximize energy production and ensure the economic viability of projects.

  Observations: Cities like *Ardebil* show higher average wind speeds, indicating favorable conditions for wind energy production. Conversely, cities such as *Abadan* and *Ardestan* have relatively lower wind speeds, which may make wind energy projects less feasible or efficient in these areas.

- **Land Cost**: Influences the upfront investment required. Locations with lower land costs are generally more attractive as they reduce initial project expenses, potentially offering a quicker return on investment.

  Observations: Cities like *Ardestan* exhibit higher land costs, potentially increasing the initial investment required for projects in these areas. On the other hand, cities such as *Abadan* display lower land costs, which could be more attractive from a cost-efficiency standpoint for project developers.

- **Transportation Cost**: Affects ongoing operational costs. Regions with lower transportation costs benefit from cheaper logistics, which can significantly reduce the overall cost of project execution and maintenance.

  Observations: Cities such as *Abadan* have relatively higher transportation costs, which could impact the total operational expenses of projects. Cities like *Ahvaz*, with lower transportation costs, offer potential cost advantages for transporting equipment and materials, enhancing project viability.

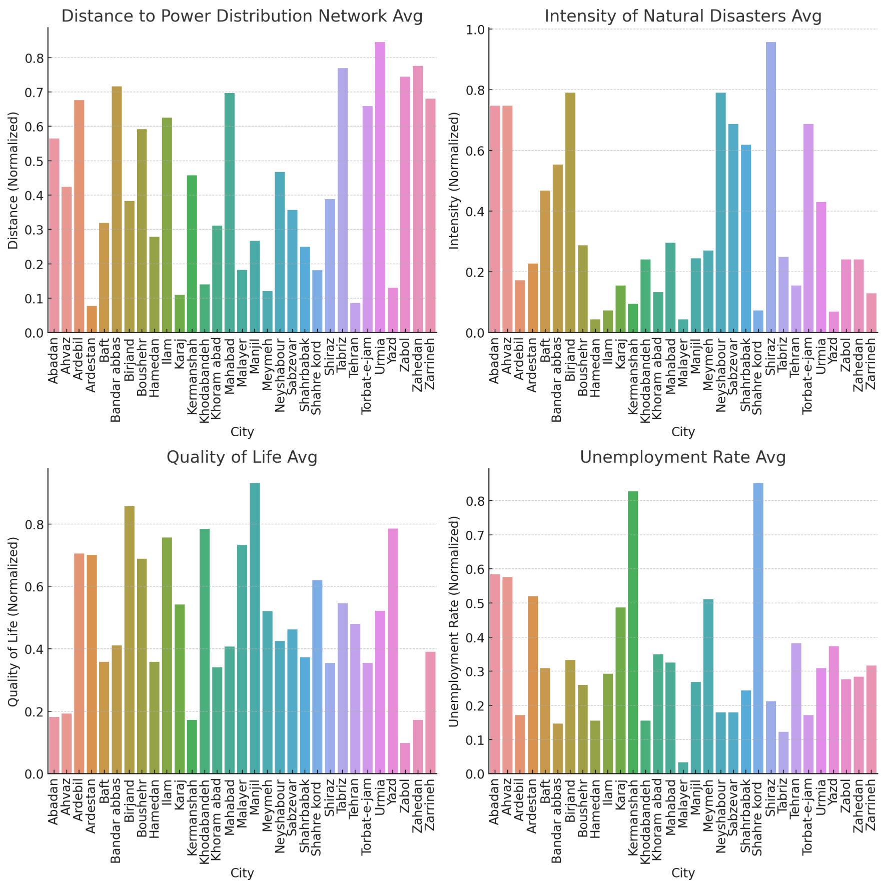

Figure 4: EDA - Factors versus Cities

- **Distance to Power Distribution Network:** The closer a city is to the power distribution network, the lower the costs and complexities associated with connecting the wind plant to the grid. Cities showing shorter distances in the analysis would be favorable in terms of infrastructure integration.

  Observations: Cities like `Ardestan` and `Abadan` show very low distances, indicating advantageous positions for projects that require grid connectivity. In contrast, cities such as `Ardebil` exhibit greater distances, which might complicate or increase the costs of projects in these areas.

- **Intensity of Natural Disasters:** Cities with lower average scores in this aspect are preferred as they suggest a lower risk of damage to the wind power infrastructure, which can significantly reduce long-term maintenance costs and operational downtimes.

  Observations: Cities like `Ahvaz` and `Ardebil` display relatively higher intensities, indicating greater risk factors for energy projects due to potential natural disasters. Cities such as `Abadan` and `Ardestan` have lower values, suggesting a safer environment for initiating projects.

- **Quality of Life:** A higher quality of life is likely to attract and retain a skilled workforce, which is vital for the ongoing operation of the plant. Moreover, it reflects on the social sustainability of the project.

Observations: *Ardebil* and *Baft* show high quality of life scores, which could facilitate smoother project implementations and better community interactions. Lower scores in cities like *Ahvaz* might reflect challenges related to community engagement or public support.

- **Unemployment Rate:** A higher unemployment rate may offer a pool of labor that could benefit from the new employment opportunities created by the wind power plant project. This factor must be balanced against the need for skilled labor specific to the renewable energy sector.

  Observations: Cities with higher unemployment rates like *Ahvaz* and *Baft* might welcome energy projects as potential employment generators. Conversely, cities with lower unemployment rates might not have employment as a driving factor for project approval but could focus more on other benefits such as environmental impact and energy production.

3 DEA Analysis

In this section, we employ a two-phase Data Envelopment Analysis to evaluate the most promising locations for wind power plants in Iran. This approach enables us to assess both the operational efficiency and the broader socio-economic impacts of each potential site. For Phase 1, we focus on technical parameters such as wind speed, land cost, and grid proximity to determine the operational viability of different locations. For Phase 2, our analysis transitions to consider governmental and societal factors, including tax incentives, employment potential, and quality of life. The two-phase DEA model is important in ensuring that our recommendations not only prioritize technical efficiency but also align with national sustainability goals and local community needs.

Phase 1: Wind Farm Perspective (Maximize Output)

Option 1: Average Wind Speed

We purposed the following input and output variable, this DEA model seeks to find the optimal Wind Farm by prioritizing Average Wind Speed:

Input:

- Land Cost
- Distance of Power Distribution Network

Output:

- Average Wind Speed

BCC Output-Oriented Model

The BCC Output-Oriented model focuses on maximizing outputs like energy production from given inputs such as land cost and grid proximity. It accounts for variable returns to scale, which makes it ideal for identifying the most efficient sites for wind power plants where increased inputs do not necessarily lead to proportionally increased outputs.

Model = BCC-O			
City Name	DMU	Score	Rank
Abadan	1	0.3296	23
Ahvaz	2	0.2365	29
Ardebil	3	0.8824	10
Ardestan	4	1	1
Baft	5	1	1
Bandar abbas	6	0.2557	27
Birjand	7	0.6843	15
Boushehr	8	0.2684	25
Hamedan	9	0.3987	18
Ilam	10	0.8318	11
Karaj	11	0.5593	16
Kermanshah	12	0.2574	26
Khodabandeh	13	1	1
Khoram abad	14	0.3384	22
Mahabad	15	0.3876	19
Malayer	16	1	1
Manjil	17	1	1
Meymeh	18	0.6934	14
Neyshabour	19	0.2686	24
Sabzevar	20	0.345	21
Shahrbabak	21	1	1
Shahre kord	22	0.4968	17
Shiraz	23	0.2046	30
Tabriz	24	0.2393	28
Tehran	25	0.9258	9
Torbat-e-jam	26	0.7673	13
Urmia	27	0.182	31
Yazd	28	1	1
Zabol	29	0.8291	12
Zahedan	30	0.3587	20
Zarrineh	31	1	1

Figure 5: BCC Output Model - Wind Farm Option 1

Interpretation

Based on this result, we can see that there are several DMU with an efficiency score of 1 including:

- Ardestan (DMU 4)
- Baft (DMU 5)

- Khodabandeh (DMU 13)
- Malayer (DMU 16)
- Manjil (DMU 17)
- Shahrbabak (DMU 21)
- Yazd (DMU 28)
- Zarrineh (DMU 31)

Non-Discretionary Model

Assume *Distance of Power Distribution Network* is a Non-Discretionary variable, we need to run a Non-Discretionary Model:

Model Name = DEA-Solver LV(V7)/ Non-discretionary(NDSC-O-V)				
City Name	DMU	Score	Rank	1/Score
Abadan	1	0.32960438	23	3.03394028
Ahvaz	2	0.2365495	29	4.227445
Ardebil	3	0.88241651	10	1.13325169
Ardestan	4	1	1	1
Baft	5	1	1	1
Bandar abbas	6	0.2557377	27	3.91025641
Birjand	7	0.68435057	15	1.46123938
Boushehr	8	0.26841734	25	3.72554171
Hamedan	9	0.3987295	18	2.50796591
Ilam	10	0.8318427	11	1.20215036
Karaj	11	0.55925151	16	1.78810426
Kermanshah	12	0.25739046	26	3.88514792
Khodabandeh	13	0.99999392	7	1.00000608
Khoram abad	14	0.33844573	22	2.95468344
Mahabad	15	0.38764992	19	2.57964711
Malayer	16	1	1	1
Manjil	17	1	1	1
Meymeh	18	0.69337742	14	1.44221599
Neyshabour	19	0.26862708	24	3.72263294
Sabzevar	20	0.34499768	21	2.8985702
Shahrbabak	21	1	1	1
Shahre kord	22	0.49676766	17	2.01301347
Shiraz	23	0.20461501	30	4.88722689
Tabriz	24	0.23934426	28	4.17808219
Tehran	25	0.92580049	9	1.08014633
Torbat-e-jam	26	0.76728441	13	1.30329768
Urmia	27	0.18196984	31	5.49541604
Yazd	28	0.99998036	8	1.00001964
Zabol	29	0.82911148	12	1.20611043
Zahedan	30	0.35865668	20	2.78818169
Zarrineh	31	1	1	1

Figure 6: Non-Discretionary Model- Wind Farm Option 1

Interpretation

Based on this result, we can see that there are several DMUs with an efficiency score of 1, including:

- Ardestan (DMU 4)

- Baft (DMU 5)
- Malayer (DMU 16)
- Manjil (DMU 17)
- Shahrbabak (DMU 21)
- Zarrineh (DMU 31)

Super Efficiency Model

The Super Efficiency model is used in DEA to identify and differentiate among decision-making units (DMUs) that are already deemed efficient in standard DEA models. In the context of siting wind power plants, employing the Super Efficiency model enables us to pinpoint locations that exceed typical efficiency standards, thus providing a deeper insight into the most advantageous sites for development.

Model Name = DEA-Solver LV(V7)/ Super-Radial(Super-BCC-O)

City Name	DMU	Score
Abadan	1	0.329604379
Ahvaz	2	0.2365495
Ardebil	3	0.882416511
Ardestan	4	1
Baft	5	1.028197185
Bandar abbas	6	0.255737705
Birjand	7	0.684350569
Boushehr	8	0.268417341
Hamedan	9	0.398729502
Ilam	10	0.8318427
Karaj	11	0.559251507
Kermanshah	12	0.257390457
Khodabandeh	13	1.077572512
Khoram abad	14	0.338445732
Mahabad	15	0.387649922
Malayer	16	1.077834179
Manjil	17	1.138972208
Meymeh	18	0.693377419
Neyshabour	19	0.268627076
Sabzevar	20	0.344997682
Shahrbabak	21	1
Shahre kord	22	0.496767664
Shiraz	23	0.204615014
Tabriz	24	0.239344262
Tehran	25	0.925800493
Torbat-e-jam	26	0.767284415
Urmia	27	0.181969844
Yazd	28	1
Zabol	29	0.829111478
Zahedan	30	0.358656685
Zarrineh	31	1.21031746

Figure 7: Super Efficiency Model- Wind Farm Option 1

Interpretation

Based on this result, we can see that there are several DMUs with an efficiency score of 1, including:

- Ardestan (DMU 4)
- Shahrbabak (DMU 21)
- Yazd (DMU 28)

And more than 1, indicating super-efficient cities:

- Baft (DMU 5)
- Khodabandeh (DMU 13)
- Malayer (DMU 16)
- Manjil (DMU 17)
- Zarrineh (DMU 31)

Option 2: Adjusted Revenue

The input variables of Option 2 are same as Option 1, but the output variable is slightly different. Since the original dataset doesn't have profit variable, we will calculate the expected profit base on the data we currently have, the formula for calculating expect Profit for each DMU are shown as follows:

$$\begin{aligned}\textbf{Adjusted Revenue}_{DMU} &= \textit{Expected Wind Power} \times \textit{Avg Electricity Price in Iran} \\ &- \textit{Land Cost} \times \textit{Avg Area needed for a Wind Farm} \\ &- \textit{Power Distribution Cost}\end{aligned} \tag{1}$$

where

- *Expected Wind Power* (KWh) = $\frac{P}{1000} \times h$, where h is the operational hour of Wind Farm in one year($365 \times 24 = 8760$ hours).
- *Avg Electricity Price in Iran* is around 5000 $Rial/KWh$ (2021) [1]
- *Land Cost*$(KRial/m^2)$ can be obtained from our original data.
- *Avg Area needed for a Wind Farm*: A Wind Farm requires 21 Acres of land on average, which is equivalent to $84984m^2$
- *Power Distribution Cost* = *Distance of Power Distribution Network*$\times$*Power Distribution Unit Cost*, however, *Power Distribution Unit Cost* is unknown. We need to run several experiment to examine how this factor affect the DEA model. Let's denote *"Power Distribution Unit Cost"* as C, where $C \in \{1, 2, 2.5\} \times 10^7$ Rial per miles in one year.

[1] Iran Electricity Price in 2021

To calculate Expected Wind Power for each DMU, we use the following formula[2]:

$$P = \frac{1}{2}\rho A v^3 \tag{2}$$

where

- P is the power in Watts
- ρ is the air density in kg/m^3, the default value is $\rho = 1.224kg/m^3$
- A is the rotor swept area (m^2). Assume we have wind turbine with radius $= 12m$, then $A = \pi r^2 = 3.14159 \times 12^2 = 452.16$. For our analysis, we set the default value of A to 452.16.
- v is the Avg Wind Speed (m/s) for each DMU, which can be obtained from our original data.

[2]Wind Energy and Power Calculations Formula

BCC Output-Oriented Model

Model = BCC-O		C=1e7		C=2e7		C=2.5e7	
City Name	DMU	Score	Rank	Score	Rank	Score	Rank
Abadan	1	0.0273	23	0.0262	23	0.0257	23
Ahvaz	2	0.0082	29	0.0073	29	0.0068	29
Ardebil	3	0.64	9	0.6396	9	0.6394	9
Ardestan	4	1	1	1	1	1	1
Baft	5	0.9072	6	0.9071	6	0.9071	6
Bandar abbas	6	0.0139	26	0.0129	26	0.0125	26
Birjand	7	0.2573	14	0.2564	14	0.256	14
Boushehr	8	0.0153	24	0.0144	24	0.0139	24
Hamedan	9	0.056	18	0.0552	18	0.0548	18
Ilam	10	0.4545	12	0.453	12	0.4522	12
Karaj	11	0.0862	16	0.0849	16	0.0842	16
Kermanshah	12	0.0121	27	0.0112	27	0.0108	27
Khodabandeh	13	0.6609	8	0.6595	8	0.6589	8
Khoram abad	14	0.0313	22	0.0301	22	0.0295	22
Mahabad	15	0.0437	19	0.0422	19	0.0414	19
Malayer	16	0.8816	7	0.8815	7	0.8814	7
Manjil	17	1	1	1	1	1	1
Meymeh	18	0.2102	15	0.2091	15	0.2086	15
Neyshabour	19	0.0143	25	0.0135	25	0.013	25
Sabzevar	20	0.034	20	0.0331	20	0.0327	20
Shahrbabak	21	1	1	1	1	1	1
Shahre kord	22	0.0667	17	0.0654	17	0.0648	17
Shiraz	23	0.0024	30	0.0016	30	0.0011	30
Tabriz	24	0.0099	28	0.0089	28	0.0084	28
Tehran	25	0.4704	10	0.4692	10	0.4685	10
Torbat-e-jam	26	0.3569	13	0.3556	13	0.3549	13
Urmia	27	0.0021	31	0.0008	31	0.0001	31
Yazd	28	0.9997	5	0.9997	5	0.9997	5
Zabol	29	0.4702	11	0.4676	11	0.4663	11
Zahedan	30	0.0334	21	0.0316	21	0.0307	21
Zarrineh	31	1	1	1	1	1	1

Figure 8: BCC Output Model - Wind Farm Option 2

Interpretation

Based on this result, we can see that there are several DMUs with an efficiency score of 1, including:

- Ardestan (DMU 4)
- Manjil (DMU 17)
- Shahrbabak (DMU 21)
- Zarrineh (DMU 31)

As C increases, the overall cost of connecting the wind farm to the power distribution network also rises. This higher cost lead to a decrease in the efficiency scores of DMUs that are farther from the power grid or those in regions where the infrastructure is less developed, as the cost becomes a more significant factor in their overall efficiency. However, the DMUs that initially appeared efficient with a lower C still remain efficient under higher C values, which implies that these city are pretty robust against increasing power distribution cost.

Non-Discretionary Model

Assume *Distance of Power Distribution Network* is a Non-Discretionary variable, we need to run a Non-Discretionary Model:

Model = NDSC-O-V		C=1e7	C=2e7	C=2.5e7
City Name	DMU	Score	Score	Score
Abadan	1	0.027281054	0.026239219	0.025717536
Ahvaz	2	0.008177117	0.007262888	0.006805141
Ardebil	3	0.640031101	0.639614865	0.639406461
Ardestan	4	0.999959242	0.999959106	0.999959037
Baft	5	0.907232036	0.907116431	0.90705852
Bandar abbas	6	0.013853707	0.012931746	0.012470151
Birjand	7	0.257265871	0.256421168	0.255998096
Boushehr	8	0.015277062	0.014381249	0.01393273
Hamedan	9	0.056047243	0.055235204	0.05482866
Ilam	10	0.454479776	0.452975344	0.452221782
Karaj	11	0.086248893	0.084857203	0.084159768
Kermanshah	12	0.012085405	0.011205283	0.010764633
Khodabandeh	13	0.660856761	0.65952795	0.658859633
Khoram abad	14	0.031270506	0.030110641	0.029529666
Mahabad	15	0.04369883	0.0421766	0.041414304
Malayer	16	0.881609747	0.881491452	0.881432216
Manjil	17	1	1	1
Meymeh	18	0.210189465	0.20911686	0.208579464
Neyshabour	19	0.014332063	0.01346535	0.013031422
Sabzevar	20	0.033992622	0.033131351	0.03270014
Shahrbabak	21	0.999988761	0.999988737	0.999988725
Shahre kord	22	0.066658797	0.065416601	0.064794262
Shiraz	23	0.002444454	0.00157306	0.001136793
Tabriz	24	0.009884118	0.008888495	0.008390019
Tehran	25	0.470426901	0.469162244	0.468527648
Torbat-e-jam	26	0.356896913	0.355588309	0.354932944
Urmia	27	0.002106704	0.000750851	7.20E-05
Yazd	28	0.99973775	0.999734464	0.99973279
Zabol	29	0.470219771	0.46760152	0.46628972
Zahedan	30	0.033366789	0.031598718	0.030713295
Zarrineh	31	1	1	1

Figure 9: Non-Discretionary Model- Wind Farm Option 2

Interpretation

Based on this result, we can see that there are several DMUs with an efficiency score of 1, including:

- Manjil (DMU 17)
- Zarrineh (DMU 31)

Phase 2: Government Perspective (Minimize Input)

Input

- Tax Exemptions
- Government Subsidies in Specific Area + Loan

Output

- Safety
- Quality of Life
- Unemployment Rate

BCC Input-Oriented Model

Model = BCC-I			Workbook
No.	DMU	Score	Rank
Abadan	1	0.1104	22
Ahvaz	2	0.2334	16
Ardebil	3	0.4386	13
Ardestan	4	0.9999	8
Baft	5	0.0408	26
Bandar ab	6	0.16	19
Birjand	7	0.9021	9
Boushehr	8	0.6487	11
Hamedan	9	0.1667	18
Ilam	10	0.3715	14
Karaj	11	1	1
Kermansh	12	1	1
Khodaban	13	0.7064	10
Khoram ab	14	0.1429	20
Mahabad	15	0.0367	27
Malayer	16	0.3326	15
Manjil	17	1	1
Meymeh	18	0.1207	21
Neyshabo	19	0.0435	25
Sabzevar	20	0.0364	28
Shahrbaba	21	0.0455	24
Shahre ko	22	1	1
Shiraz	23	0.5	12
Tabriz	24	1	1
Tehran	25	1	1
Torbat-e-j	26	0.0339	29
Urmia	27	0.1808	17
Yazd	28	1	1
Zabol	29	0.0265	31
Zahedan	30	0.0323	30
Zarrineh	31	0.0769	23

Figure 10: BCC Input-Oriented Model - Government Perspective

Interpretation

Based on this result, we can see that there are several DMUs with an efficiency score of 1, including:

- Karaj (DMU 11)
- Kermanshah (DMU 12)
- Manjil (DMU 17)
- Shahre kord (DMU 22)
- Tabriz (DMU 24)
- Tehran (DMU 25)
- Yazd (DMU 28)

They're producing the best possible output for the current level of input. In contrast, Zabol, Sabzevar, Mahabad and Torbate-e-jam have relatively low efficiency scores, indicating that the subsidies that may be invested do not get much of the increase in public services in terms of increased public benefits.

Non-Discretionary Model

Model Name = DEA-Solver LV(V7)/ Non-discretionary(NDSC-O-V)

City Name	DMU	Score
Abadan	1	0.90426865
Ahvaz	2	0.99999509
Ardebil	3	0.71653543
Ardestan	4	0.86754967
Baft	5	0.98498325
Bandar abbas	6	0.99992134
Birjand	7	0.35103245
Boushehr	8	0.22580645
Hamedan	9	1
Ilam	10	0.07817259
Karaj	11	1
Kermanshah	12	1
Khodabandeh	13	0.89037433
Khoram abad	14	0.56739823
Mahabad	15	0.4767967
Malayer	16	1
Manjil	17	0.94633643
Meymeh	18	0.33774834
Neyshabour	19	0.50805328
Sabzevar	20	0.7411034
Shahrbabak	21	0.95330062
Shahre kord	22	0.73509934
Shiraz	23	0.99999344
Tabriz	24	1
Tehran	25	1
Torbat-e-jam	26	0.28158747
Urmia	27	0.56651435
Yazd	28	0.74070543
Zabol	29	0.99996419
Zahedan	30	0.75361044
Zarrineh	31	0.57774887

Figure 11: Non-Discretionary Model- Government Perspective

Interpretation

Based on this result, we can see that there are several DMUs with an efficiency score of 1, including:

- Hamadan (DMU 9)
- Karaj (DMU 11)
- Kermanshah (DMU 12)
- Malayer (DMU 16)
- Tabriz (DMU 24)
- Tehran (DMU 25)

At the current level of subsidies, they have achieved an optimal state in terms of employment and quality of life. This means that, compared to other cities, these areas maximize public benefits (i.e., improving employment rates and quality of life) through controllable inputs, such as tax exemptions, governmental subsidies, and low-interest loans. Therefore, they may be among the ideal locations for power plant siting, as relatively less additional subsidy might further enhance local public benefits.

Super Efficiency Model

Model Name = DEA-Solver LV(V7)/ Super-Radial(Super-BCC-I)		
City Name	DMU	Score
Abadan	1	0.1045008913
Ahvaz	2	0.2345679012
Ardebil	3	0.438576349
Ardestan	4	1.010357143
Baft	5	0.04081591837
Bandar abbas	6	0.1599984
Birjand	7	0.897021909
Boushehr	8	0.6486742424
Hamedan	9	0.166665
Ilam	10	0.3715072806
Karaj	11	1
Kermanshah	12	1.295392954
Khodabandeh	13	0.7063973064
Khoram abad	14	0.1428557143
Mahabad	15	0.03669688073
Malayer	16	0.3325679296
Manjil	17	1
Meymeh	18	0.1153846154
Neyshabour	19	0.04347782609
Sabzevar	20	0.03636327273
Shahrbabak	21	0.04545409091
Shahre kord	22	1
Shiraz	23	0.499995
Tabriz	24	1.350746269
Tehran	25	2.5
Torbat-e-jam	26	0.0338979661
Urmia	27	0.1808113227
Yazd	28	2.612724961
Zabol	29	0.02648980132
Zahedan	30	0.03225774194
Zarrineh	31	0.07692230769

Figure 12: Super Efficiency Model- Government Perspective

Interpretation

Based on this result, we can see that there are several DMUs with an efficiency score of 1, including:

- Ardestan (DMU 4)
- Karaj (DMU 11)
- Manjil (DMU 17)
- Shahre kord (DMU 22)

And more than 1, indicating super-efficient cities:

- Kermanshah (DMU 12)
- Tabriz (DMU 24)
- Tehran (DMU 25)

- Yazd (DMU 28)

The DMUs for these cities are valid, where DMUs that score more than 1 show superefficiency under the current model Settings. This shows that they produce the expected output with their inputs and exceed the optimal output level under the conventional efficiency model. This could mean they use inputs such as tax incentives, government subsidies, and cheap loans more effectively to improve output indicators such as unemployment rate, quality of life, and safety.

4 Recommendation

	Phase:	Phase 1- Wind Speed			Phase 1 - Revenue		Phase 2 -Government		
#	DMU\Model	BCC-O	NDSC-O	Super-O	BCC-O	NDSC-O	BCC-I	NDSC-I	Super-I
1	Abadan								
2	Ahvaz							☐	
3	Ardebil								
4	Ardestan	✓	✓	✓	✓	✓	☐		✓
5	Baft	✓	✓	✓				☐	
6	Bandar abbas							☐	
7	Birjand								
8	Boushehr								
9	Hamedan							✓	
10	Ilam								
11	Karaj						✓	✓	✓
12	Kermanshah						✓	✓	✓
13	Khodabandeh	✓	☐	✓					
14	Khoram abad								
15	Mahabad								
16	Malayer	✓	✓	✓				✓	
17	Manjil	✓	✓	✓	✓	✓	✓	☐	✓
18	Meymeh								
19	Neyshabour								
20	Sabzevar								
21	Shahrbabak	✓	✓	✓	✓	✓			
22	Shahre kord						✓		✓
23	Shiraz							☐	
24	Tabriz						✓	✓	✓
25	Tehran						✓	✓	✓
26	Torbat-e-jam								
27	Urmia								
28	Yazd	✓	☐	✓	☐	☐	✓		✓
29	Zabol							☐	
30	Zahedan								
31	Zarrineh	✓	✓	✓	✓	✓			

Table 2: Summary of different DEA model, where ✓ indicates Efficient DMUs, and ☐ represent DMU with efficiency score close to 1 (e.g. 0.99)

Based on the comprehensive Data Envelopment Analysis presented, we can make informed recommendations for the optimal site for a wind power plant in Iran, considering both the plant's own efficiency and the enhancement of public benefits.

For the wind power plant's efficiency perspective, locations like Ardestan (DMU 4), Manjil (DMU 17), Shahrbabak (DMU 21) and Zarrineh (DMU 31) consistently show high efficiency scores across multiple DEA models, indicating their superior potential for energy production. These locations offer advantageous conditions such as optimal wind speeds, favorable distances to power distribution networks, and economic feasibility in terms of land and transportation costs. Specifically, Manjil and Ardestan demonstrate not only the capacity to maximize output but also the capability to operate with high efficiency under various constraints, including non-discretionary factors like proximity to power infrastructure.

From the standpoint of maximizing public benefits, which include safety, quality of life, and lowering unemployment rates, Manjil (DMU 17) again stands out as a favorable location. This site aligns with government strategies aiming to foster social sustainability and economic development. The establishment of a wind power plant in Manjil could catalyze local job creation, improve the quality of life by enhancing local infrastructure, and contribute to long-term environmental and social goals.

Therefore, it is recommended that the wind power plant be situated in **Manjil (DMU 17)**. This recommendation is based on the site's capacity to fulfill high efficiency in power production and its potential to significantly contribute to the public benefits envisioned by government policies. Establishing the plant in Manjil will not only ensure optimal use of resources but will also support broader strategic objectives, including environmental sustainability, economic diversification, and social stability.