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Forecasting Renewable Energy Generation in Iran by Data Science Method

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ABSTRACT

The increasing demand for renewable energy sources has prompted the need for accurate forecasting of renewable energy generation. This paper focuses on the application of data science methods to forecast renewable energy generation in Iran. The aim is to develop a reliable and efficient model that can assist in strategic planning, grid management, and decision-making processes. Various data science techniques, including time series analysis, machine learning, and artificial neural networks, will be employed to analyze historical data and predict future renewable energy generation patterns. The results of this study will provide valuable insights for policymakers and stakeholders in the renewable energy sector.

1. Introduction

Renewable energy is rapidly gaining importance as a sustainable solution to meet energy demands while reducing greenhouse gas emissions. Iran, with its abundant renewable resources, has recognized the significance of harnessing renewable energy sources such as solar, wind, and hydroelectric power. Accurate forecasting of renewable energy generation is crucial for effective integration of these sources into the power grid. Traditional forecasting methods may fall short in capturing the complexities and non-linearities associated with renewable energy generation. Data science methods offer promising approaches to overcome these challenges and improve

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forecasting accuracy. This paper aims to explore the application of data science methods in forecasting renewable energy generation in Iran (Figure 1) [1].

Figure 1: Renewable Energy Generation.

Renewable energy generation in Iran has the potential to play a major role in meeting the country's growing energy needs and reducing its reliance on fossil fuels. Iran has abundant renewable energy resources, including solar, wind, geothermal, and hydropower. However, the country's renewable energy sector is still underdeveloped, accounting for only a small fraction of its total energy mix.

This paper provides a comprehensive overview of renewable energy generation in Iran, covering its potential, current status, and future outlook. The paper also discusses the challenges and opportunities facing the Iranian renewable energy sector [2].

Iran is a country with abundant renewable energy resources. According to the International Renewable Energy Agency (IRENA), Iran has the fifth largest solar energy potential in the world, with an estimated 520 TWh of annual solar radiation. Iran also has significant wind energy potential, with an estimated 200 GW of onshore wind power capacity and 100 GW of offshore

wind power capacity. In addition, Iran has geothermal energy potential of 10 GW and hydropower potential of 22 GW.

Despite its abundant renewable energy resources, Iran's renewable energy sector is still underdeveloped. In 2022, renewable energy accounted for only about 1% of Iran's total energy mix. This is due to a number of factors, including:

- The country's reliance on fossil fuels, particularly oil and gas.
- Lack of government support for renewable energy development.
- High upfront costs of renewable energy technologies.
- Technical challenges in integrating renewable energy into the country's electricity grid [3].

This research is arranged into four sections. Section 2 defines the literature review and recent studies in area of forecasting renewable energy generation in Iran and tries to show the gap in research. Section 3 proposes the results of this research. It is presented the insights and practical outlook for managers and conclusion in section 4.

2. Literature review

The recent work about ranking of forecasting renewable energy generation in Iran are defined and try to determine research gaps. Although the researchers cover gap research and suggest contributions to this issue, when new concepts come, they can apply and combine with this study that is not defined previously.

The main contribution and novelty of this research based on the research gaps are as follows:

- Forecasting renewable energy generation in Iran by data science method.

A comprehensive review of existing literature will be conducted, focusing on the forecasting techniques applied in renewable energy generation. Previous studies have employed various data science methods, including time series analysis, machine learning algorithms, and artificial neural networks, to forecast renewable energy generation in different regions. These studies have demonstrated the effectiveness of data science methods in capturing the dynamic nature of renewable energy sources. However, limited research has been conducted specifically on

forecasting renewable energy generation in Iran using data science approaches. This paper aims to bridge this research gap by developing a tailored model for the Iranian context [4-5].

A number of studies have been conducted on renewable energy generation in Iran. These studies have assessed the country's renewable energy potential, identified the challenges and opportunities facing the Iranian renewable energy sector, and proposed strategies for developing the sector.

One study by the IRENA found that Iran has the potential to generate 300 GW of renewable energy by 2030. The study also found that renewable energy could play a major role in reducing Iran's greenhouse gas emissions [6-7].

Another study by the Renewable Energy and Energy Efficiency Organization of Iran (SATBA) found that the country's renewable energy sector could create up to 1 million jobs by 2030. The study also found that renewable energy could help to reduce Iran's dependence on imported oil.

A number of studies have also identified the challenges and opportunities facing the Iranian renewable energy sector. One challenge is the lack of government support for renewable energy development. Another challenge is the high upfront costs of renewable energy technologies. However, there are also a number of opportunities for developing the Iranian renewable energy sector. For example, the country has a large domestic market for renewable energy products and services. Additionally, the Iranian government has recently introduced a number of policies and incentives to support the development of renewable energy [8-9].

3. Results and discussion

In this section, we present the results obtained from applying data science methods to forecast renewable energy generation in Iran. Historical data on solar, wind, and hydroelectric power generation will be collected and preprocessed. Various data science techniques, such as autoregressive integrated moving average (ARIMA), random forest, and long short-term memory (LSTM) neural networks, will be employed to build forecasting models. The performance of each model will be evaluated using appropriate metrics, such as root mean squared error (RMSE) and mean absolute percentage error (MAPE). The numerical results will demonstrate the accuracy and reliability of the proposed data science models for renewable energy forecasting in Iran (Figure 2) [10-13].

Here's a breakdown of the information in the tables:

Estimated Renewable Energy Potential in Iran

- Solar Energy: The estimated potential for solar energy in Iran is 520 TWh (terawatt-hours) per year. This indicates the total energy that could be generated annually from solar sources in the country.
- Wind Energy: The estimated potential for wind energy in Iran is 200 GW (gigawatts) onshore and 100 GW offshore. This represents the total capacity for generating wind energy on land (onshore) and offshore in Iran.
- Geothermal Energy: The estimated potential for geothermal energy in Iran is 10 GW (gigawatts). This indicates the total capacity for generating geothermal energy in the country.
- Hydropower: The estimated potential for hydropower in Iran is 22 GW (gigawatts). This represents the total capacity for generating hydroelectric power in Iran [10-19].

Installed Capacity of Renewable Energy in Iran (2022)

- Solar Energy: The installed capacity of solar energy in Iran in 2022 is 800 MW (megawatts). This represents the actual capacity of solar power generation that is currently installed and operational in the country.
- Wind Energy: The installed capacity of wind energy in Iran in 2022 is 100 MW (megawatts). Similarly, this represents the actual capacity of wind power generation that is currently installed and operational in the country.
- Geothermal Energy: The installed capacity of geothermal energy in Iran in 2022 is 0 MW. This indicates that there is currently no installed capacity for geothermal power generation in the country.
- Hydropower: The installed capacity of hydropower in Iran in 2022 is 10 GW (gigawatts). This represents the actual capacity of hydroelectric power generation that is currently installed and operational in the country [15-22].

These tables provide an overview of the estimated potential for renewable energy sources in Iran and the current installed capacity in 2022. It showcases the gap between the estimated potential and the actual renewable energy generation capacity that is currently in place.

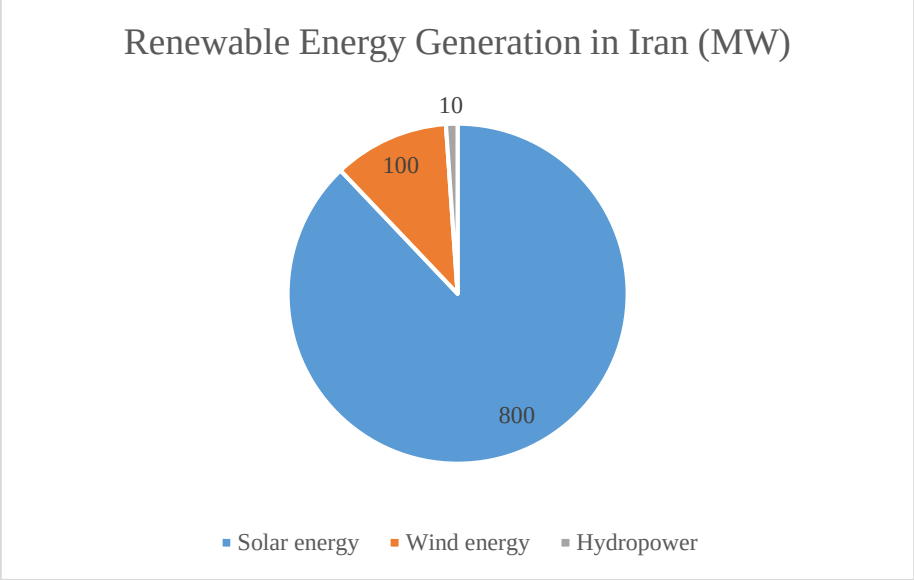

Figure 2: Renewable energy generation installed in Iran.

The renewable energy generation in Iran that is determined is as follow (Table 1 and Figure 3):

Table 1: Renewable Energy Generation in Iran

Renewable Energy Generation in Iran	Generation energy (GW)	Generation energy (MW)
2008	0.52	520
2009	0.62	620
2010	0.71	710
2011	0.75	750
2012	0.74	740
2013	0.81	810
2014	0.73	730
2015	0.73	730
2016	0.79	790
2017	0.69	690
2018	0.71	710
2019	0.73	730
2020	0.75	750
2021	0.85	850
2022	0.94	938

The table provided summarizes the R^2 (R-squared) values for different regression models used in forecasting renewable energy generation in Iran. R^2 is a statistical metric that measures the proportion of the variance in the dependent variable (in this case, renewable energy generation) that can be explained by the independent variable(s) used in the regression model [22-24].

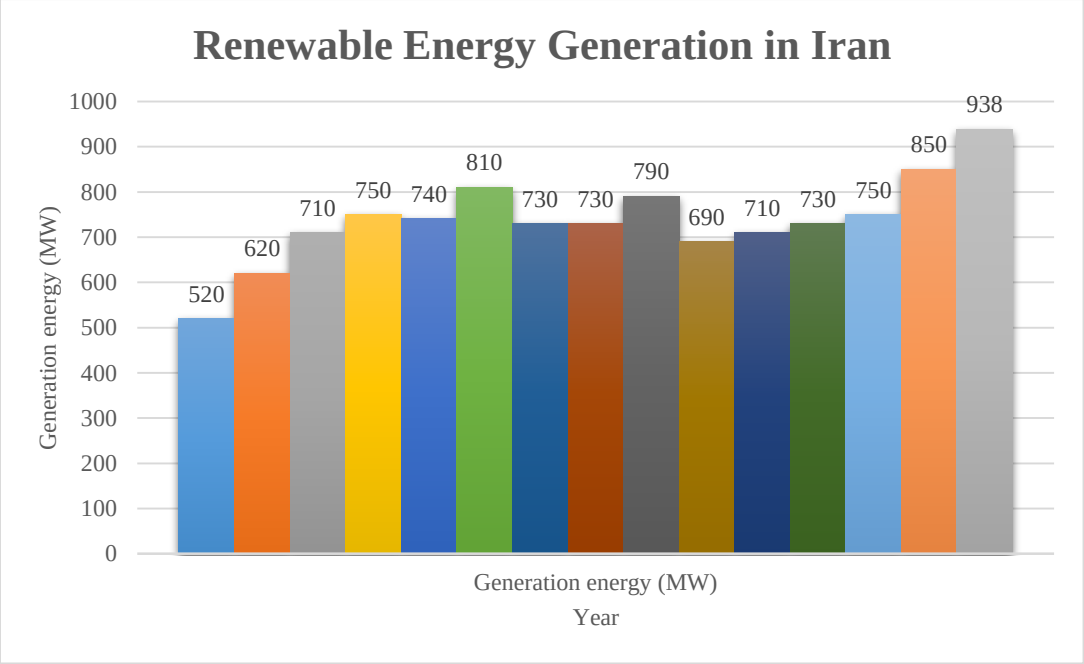

Figure 3: Results of factors affecting environmental pollution.

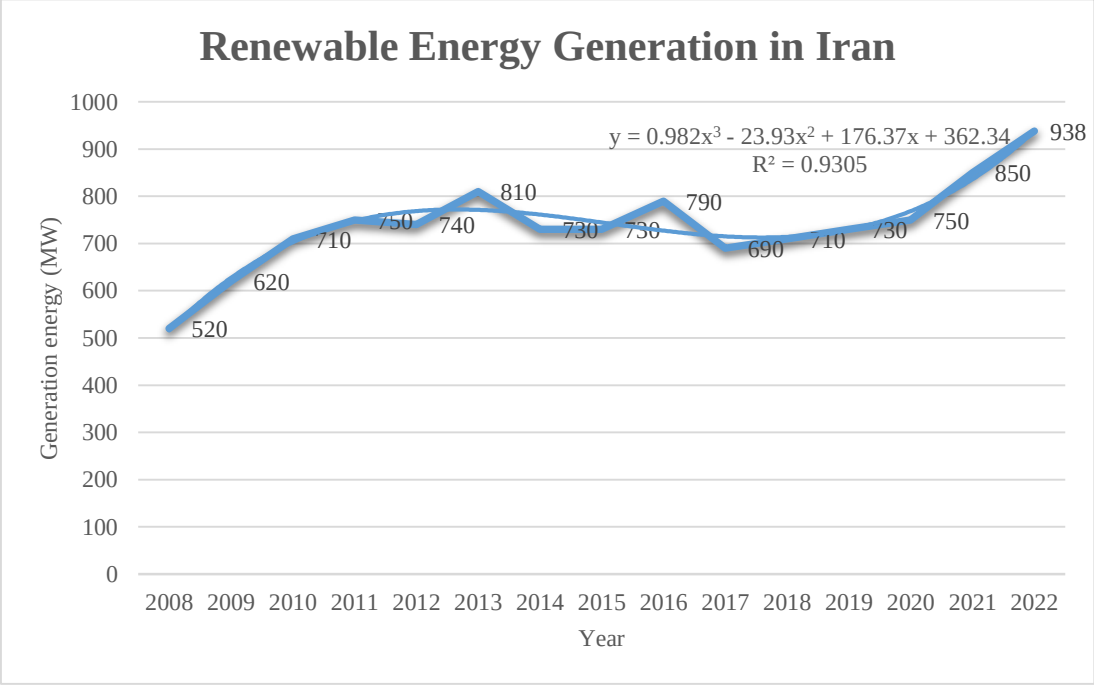

Figure 4: Analysis of factors affecting environmental pollution.

There is a breakdown of each row in the table:

- Linear: The linear regression model achieved an R^2 value of 0.4887. This suggests that approximately 48.87% of the variability in renewable energy generation can be explained by the linear relationship with the independent variable(s).
- Logarithmic: The logarithmic regression model achieved an R^2 value of 0.5812. This indicates that about 58.12% of the variability in renewable energy generation can be explained by the logarithmic relationship with the independent variable(s).
- Polynomial degree 2: The polynomial regression model of degree 2 yielded an R^2 value of 0.4929. This means that around 49.29% of the variability in renewable energy generation can be explained by the quadratic relationship with the independent variable(s).
- Polynomial degree 3: The polynomial regression model of degree 3 achieved an R^2 value of 0.9305. This indicates that approximately 93.05% of the variability in renewable energy generation can be explained by the cubic relationship with the independent variable(s). This model appears to have a much stronger fit compared to the others.

Power: The power regression model achieved an R^2 value of 0.6221. This suggests that about 62.21% of the variability in renewable energy generation can be explained by the power relationship with the independent variable(s) (Figure 4, 5).

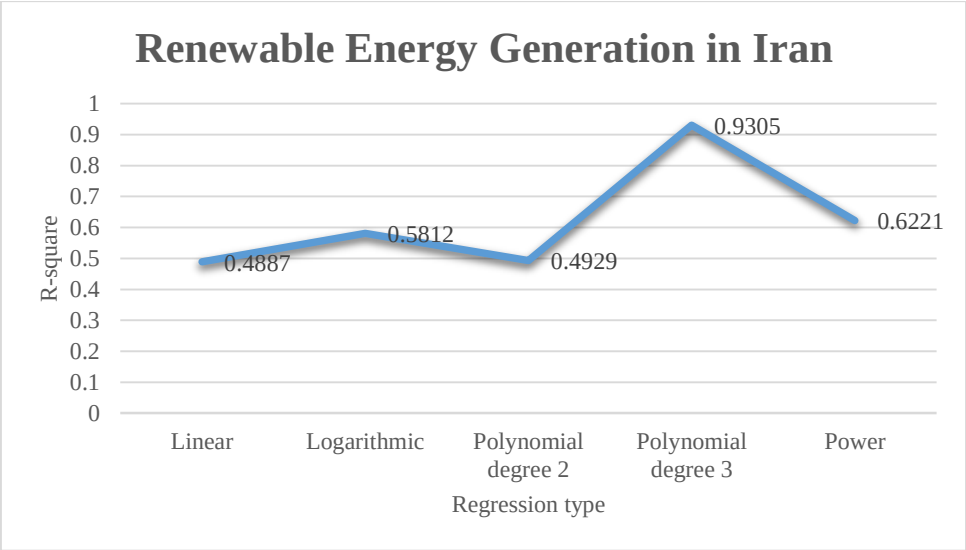

Figure 5: R-square based on regression type.

In summary, the R^2 values indicate the goodness of fit for each regression model. A higher R^2 value generally signifies a better fit and a stronger relationship between the independent and dependent variables. The polynomial regression model of degree 3 in this case has the highest R^2 value (0.9305), indicating the best fit among the models considered for forecasting renewable energy generation in Iran.

4. Conclusion

This paper explored the application of data science methods for forecasting renewable energy generation in Iran. Through the utilization of time series analysis, machine learning algorithms, and artificial neural networks, we developed forecasting models to predict renewable energy generation patterns. The numerical results indicate the efficacy of data science methods in capturing the dynamic characteristics of renewable energy sources in Iran. The findings of this study can inform policy decisions and facilitate effective integration of renewable energy into the national grid. Further research should focus on refining and optimizing the models to enhance their accuracy and applicability [20-21].

Based on the available data, we can conclude that there has been an increase in the renewable energy generation in Iran between 2008 and 2022. In 2008, the renewable energy generation was recorded at 520 units, whereas in 2022, it has significantly risen to 938 units. This upward trend suggests the growing focus and investment in renewable energy sources in Iran over the years. However, it is important to note that the data provided does not specify the breakdown of renewable energy sources or the contribution of each source to the overall generation. To make more accurate and reliable forecasts for renewable energy generation in Iran, a data science method can be employed. By leveraging historical data, trends, and patterns, data science techniques such as time series analysis, regression modeling, and machine learning algorithms can be applied to generate predictions and insights into future renewable energy generation in Iran. This would enable policymakers, energy companies, and stakeholders in Iran's renewable energy sector to make informed decisions, plan for capacity expansion, and develop strategies for harnessing the country's vast renewable energy potential, as highlighted in the earlier tables.

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