Prediction of Energy Production from Oil and Natural Gas with Artificial Neural Networks: The Example of Iraq

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Abstract

Energy is an indispensable necessity for human life. Human life shows an energy-based development. This energy needs of developing societies tend to increase continuously due to demographic, social, and economic factors. Every society attempts to meet this increasing energy need by using certain resources. Iraq mostly uses natural gas and oil to meet its expanding energy needs. In this study, the amount of energy that Iraq will produce from oil and natural gas for ten years has been estimated by using the artificial neural network model, which is used in many fields due to its high estimation skills. The amount of energy produced from natural gas and oil in Iraq between 1972 and 2022 was taken as annual data. After training the data, the weights with the lowest error margin were determined, and the estimation was made. A different 10-year energy production estimate for natural gas and oil was created using the artificial neural network. Iraq is predicted to produce energy mostly by using fossil fuels such as oil and natural gas between 2023 and 2032. This study will be a helpful resource for the Iraqi government in shaping its future energy policy.

Keyword: *Natural gas, Oil, Artificial Neural Network*

1. Introduction

Energy is one of the essential elements of human life. Energy has a wide usage area in human life. Energy is needed for enlightenment, heating, transportation, production of the goods and services that we use, and the operation of machines and devices that make our lives easier. From the past to the present, the need for energy has increased continuously with the development of technology, the spread of mechanization in many areas, and population growth. Meanwhile, energy is an indispensable economic growth and development requirement. There is a positive relationship between energy consumption and economic growth. As energy consumption increases, the gross domestic product increases. (Yanktepe et al., 2021). It is one of the primary problems that societies face in producing the amount of energy needed for the continuity and development of their technological and economic gains. Countries use renewable sources such as sun, waves, tides, wind, plant wastes, biomass, non-renewable sources including coal, oil, natural gas as well as nuclear energy production. According to the BP 2020 world energy report, the first three energy sources with the largest share of the world's total energy production in 2020 were oil, coal, and natural gas, respectively. Countries try to produce the amount of energy they need by using their energy resources. Iraq is one of the countries trying to meet the increasing energy needs. According to the information received from the BP&Data Shift portal, energy consumption per capita in Iraq increased from 2,782 kWh in 1965 to 13,847 kWh in 2021. Thus, total energy consumption increased from 23 TWh to 590 TWh over the years. It is clear that Iraq's energy needs is increasing contiuously. According to the BP Energy Report 2021, Iraq produces 69.51% of its energy needs using oil and 28.99% using natural gas resources. Estimating the amount of energy production in the future has an essential role in evaluating future economic and energy policies. In this study, the amount of energy that Iraq will obtain from oil and natural gas is etimated in the following ten years by means of artificial neural network model.

Artificial Neural Network (ANN) is a data processing technique based on artificially imitating human brain nerve cells connected withcomputer systems to solve complex problems. ANN performs the learning process using the examples given to it (Basheer and Hajmeer, 2000).

2. Literature Review

The ANN model has been used in many energy production forecasting studies because it has high predictive ability. In this regard, some of the previously conducted studies and their results are given below.

The amount of electrical energy obtained from renewable and non-renewable energy sources has been assessed. Işık and Şeker (2021) used the ANN model to estimate the amount of energy production in Turkey. After testing the obtained results, it has been shown that the artificial neural network model can be used with high accuracy in estimating the amount of energy production.

Rodriguez, Fleetwood, et al. (2018) estimated the amount of energy production from solar panels using the ANN model. As a result of the study, errors in the range of 0.5%–9% were determined between the estimated and actual production amounts. The accuracy of the model was deemed sufficient for solar energy predictions.

Moreover, Cantürk (2018) estimated the short-term electricity generation from a wind farm in Turkey using the ANN model. They concluded that the resulting deviations were within an acceptance range.

Also, Şenol and Musayev (2017) estimated electricity generation from wind energy by creating an ANN with various wind turbines. As a result of the study, it was found that the predicted results of the model were consistent and reliable. It has been concluded that the artificial neural network model can be used to predict the amount of wind energy production.

Akgürbüz (2017) estimated the energy production amount of Gökçekaya dam using the ANN model. As a result of the analysis, a high simulation rate of 92.955% was obtained. It was concluded that the ANN model can be used to estimate the amount of energy production.

Makas and Karaatl (2016) made a multi-period estimation of hydroelectric power generation with ANN. Using the data between 2007 and 2013 for Aksu HEPP, the 12-month production value in 2014 was estimated with high accuracy. After the model successfully passed the test phase, the expected 12-month electricity production for 2015 was estimated.

Şahan and Okur (2016) estimated solar energy with the help of the ANN model by using meteorological data in the Mediterranean Region. Using the meteorological and geographical data between 1993 and 2010, results with an accuracy of 94.1562% were obtained with the ANN model.

Further,İnallı, Işık, and Dağtekin(2014) estimated the efficiency and production amount of the Karakaya hydroelectric power plant by using the ANN model. With the artificial neural network model created, the efficiency and production of the Karakaya hydroelectric power plant were estimated with high precision.

Eren (2010) used the ANN model to predict energy production from household waste. It took the 900-day energy production data of the facilities producing energy from the garbage in Istanbul as input, made an estimate, and obtained meaningful results.

The last but not least, Mabel and Fernandez (2007) estimated the amount of wind energy production in an Indian Region using the ANN method. Wind speed, relative humidity, and production time were taken as inputs, and data between 2002 and 2005 were included in the analysis. When the simulated and real results were compared, the model's accuracy was significant.

3. Material and Method

The artificial neural network model creates a simple model of the nervous system in the brain on a computer and applies the features of the brain, such as learning, association, classification, and generalization. The ANN, which is based on the neuron, which is the essential element of the brain, in a sense, tries to simulate the way the neuron works simply. (Öztürk and Şahin, 2018).

Artificial neural networks are computer systems developed to realize new abilities such as deriving information creating and discovering new knowledge through learning, which is one of the characteristics of the human brain, without any help (Öztemel 2003). The ANN model emerged in 1943 by Warren McCulloch, a neurosurgeon, and Walter Pitts, a mathematician, in an article titled A logical calculation of Thoughts in Neural Activity (Url, 1. 2016).

Natural neurons receive signals through synapses on dendrites. If these signals are strong enough to exceed the threshold, the neuron is activated and these signals can go to another synapse and be activated in other neurons. The working principle of natural neurons is shown in the figure below.

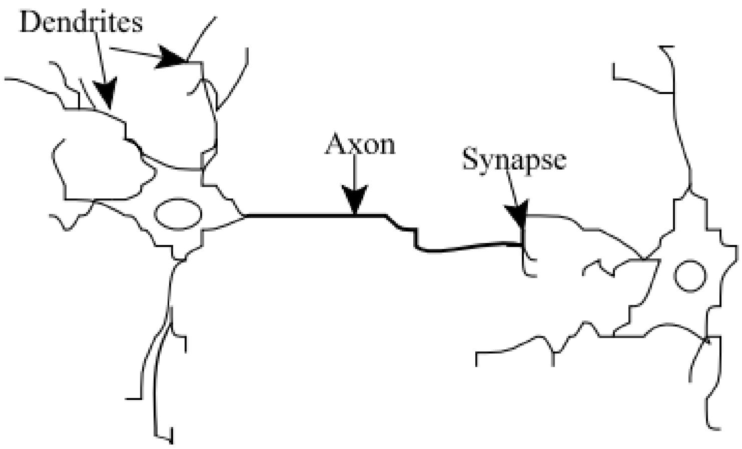


Figure 3.1. Neural network model (Gersherson, 2023)

The figure below illustrates the natural neural network's operation and how it is applied to the artificial neural network.. Input (synapse), weight (strength of the relevant signal), activation function (a mathematical function that calculates the activation of the neuron), and output (another function that calculates the result of the artificial neuron).

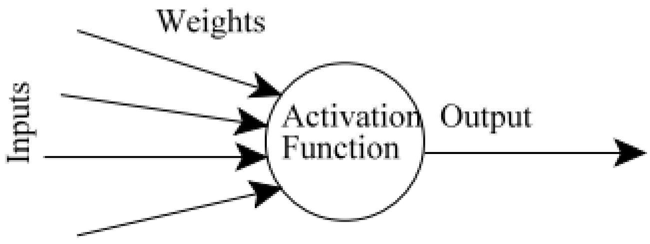


Figure 3.2. Artificial neural network model (Gersherson, 2023)

The following figure shows the artificial neural network architecture with formulae.

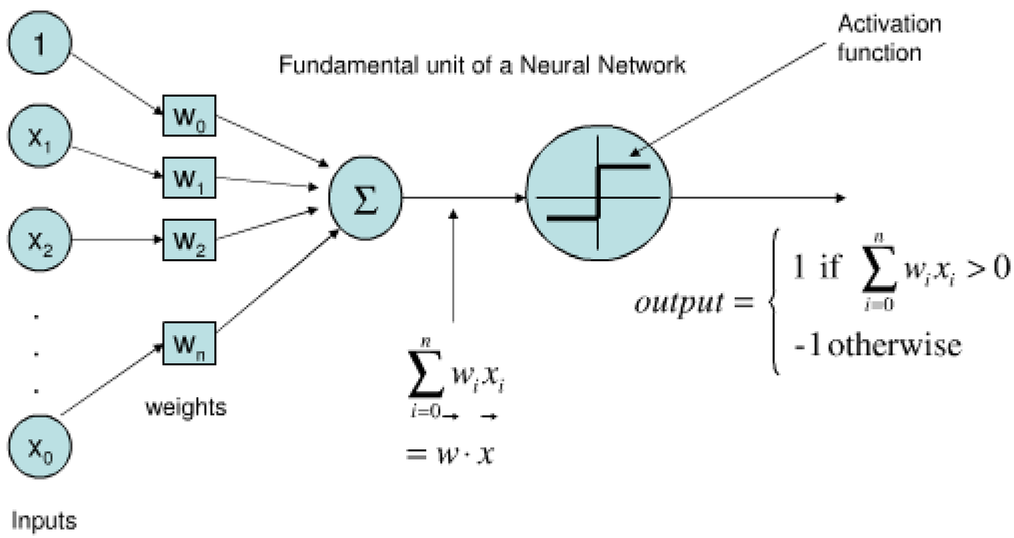


Figure 3.3. An artificial neural network model with formulas(Url. 2023).

From the past to the present, the ANN model has been developed and used in many areas. It is used in various fields, such as fault analysis and determination, financial applications, medical applications, defense industry applications, communication applications, production applications, automation and control applications, and forecasting. (Arıkan Kargı, 2013)

ANNs are single-layer, multilayer, feedforward ANNs, and feedback ANNs, which can be divided into four groups as ANN models. (Öztürk and Şahin, 2018)

The most widely used ANN model type nowadays is multilayer perceptron networks. These networks consist of three layers.

1st input layer: Is the layer where data input is made.

2nd middle layer: (hidden layer) is where the data is processed. The number of middleware may increase depending on the relationship between input and output.

3rd output layer finds the output produced by processing the data from the middleware.

The number of process elements between input and output varies according to the problem. (öztemel. 2012)

3.1. Model Selection Criteria

Root mean square error(RMSE): RMSE= $\sqrt{\frac{1}{m}\sum_{i=1}^{m}(X_i - Y_i)^2}$

Mean of absolute square error(MAE): MAE= $\frac{1}{m}\sum_{i=1}^{m}[X_i - Y_i]^2$

Mean absolute percentage error(MAPE) MAPE= $\frac{1}{m}\sum_{i=1}^{m}\left|\frac{Y_i - X_i}{Y_i}\right|$

(Chicco et al… 2021).

Theil's U $= \frac{\left[\sum_{i=1}^{m}(P_i - A_i)^2\right]^{1/2}}{\left[\sum_{i=1}^{m} A_i^2\right]^{1/2}}$ (Glen, Url, 2023)

A= Change in actual earnings.

P= Predicted change in earnings.

4. Findings and Analysis

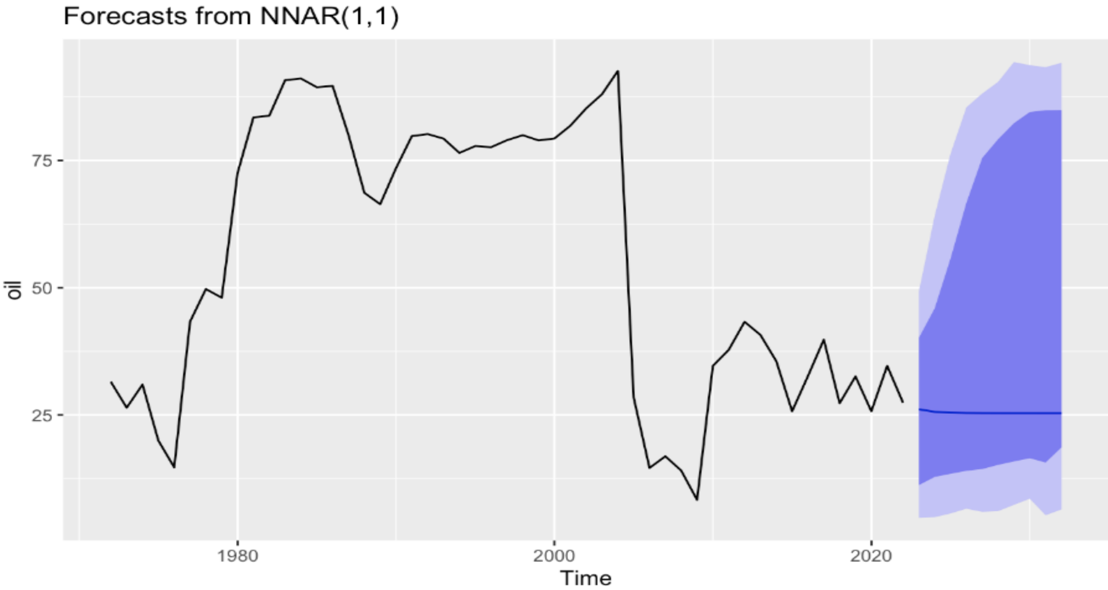
This study attempted a 10-year forecast of Iraq's energy production from oil and natural gas. The data used in the study belong to a time period between 192–2022, and they were taken from the official website of the World Bank. R program was applied for the analysis. The study used the ANNs forecasting method, and the analysis results are shown in detail below.

Table 3.1. Selection of the appropriate Fold value for energy production from oil.

	RMSE	**MAE**	**MAPE**	**Theil's U**
Fold 1	10.476	7.681	29.699	3.041
Fold 2	21.701	13.666	28.089	3.065
Fold 3	7.960	6.532	20.140	1.001
Fold 4	7.389	6.165	13.998	0.832
Fold 5	12.247	9.435	17.914	1.217

Table 3.1. shows the choice of the appropriate Fold value for energy production from oil. Theil's U statistic compares the predictive performance of more complex and mechanical forecasting models. A Theil's U statistic less than 1 indicates the appropriate Fold value. When the table is analyzed, Theil's U value of Fold 4 is less than 1, and the reasonable Fold value is 4 (0.832). In addition, according to the RMSE, MAE, and MAPE values of the model selection criteria, it is observed that these values are the smallest in Fold 4. In this case, Theil's U value was supported, and it was decided that Fold 4 was the appropriate choice. The graph of the prediction of energy production from oil for the next ten years is illustrated below.

Graph 3.1. A 10-year forecast of energy production from oil.



Graph 3.1. shows the energy production from oil for ten years. When the graph is analyzed, it is observed that energy production from oil for the next ten years is similar to the previous years. This situation is given with numerical data in Table 3.2. below.

Table 3.2. 10-year forecast of energy production from oil.

Index	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
2023	26.113	11.220	40.142	4.804	49.236
2024	25.613	12.834	45.955	4.920	64.140
2025	25.445	13.447	55.738	5.651	76.324
2026	25.391	14.031	66.670	6.584	85.434
2027	25.373	14.379	75.491	5.970	88.149
2028	25.368	15.198	79.170	6.101	90.443
2029	25.366	15.875	82.319	7.341	94.342

2030	25.366	16.509	84.517	8.545	93.721
2031	25.366	15.658	84.874	5.303	93.331
2032	25.366	18.633	84.907	6.441	94.194

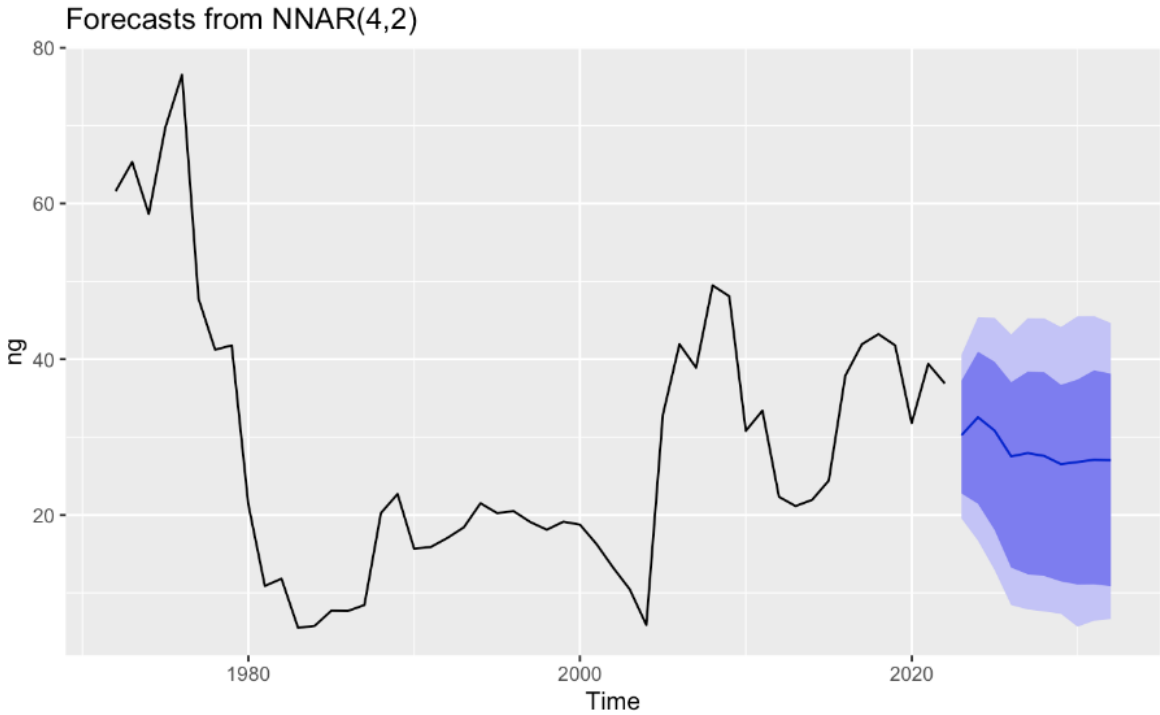
Table 3.2. above presents the 10-year forecast of energy production from oil with numerical data. When the table is analyzed, there is a very small decrease between 2024-2028 and a stable course of energy production from oil between 2029-2032.

Table 3.3. Selection of the appropriate Fold value for energy production from natural gas.

	RMSE	MAE	MAPE	Theil's U
Fold 1	7.043	6.167	28.978	1.602
Fold 2	6.449	6.356	14.171	0.538
Fold 3	10.213	6.780	19.472	1.293
Fold 4	10.104	7.339	49.244	3.989
Fold 5	5.265	7.889	21.322	1.204

Table 3.3. shows the appropriate Fold value selection for power generation from natural gas. Theil's U statistic allows a comparison of the predictive performance of a more complex and mechanical forecasting model. A Theil's U statistic less than 1 indicates the appropriate Fold value. When the table is analyzed, Theil's U value of Fold 2 is less than 1, and the appropriate Fold value is 2 (0.538). In addition, according to the RMSE, MAE, and MAPE values of the model selection criteria, it is observed that these values are the smallest in Fold 2. In this case, Theil's U value was supported, and it was determined that Fold 2 was the appropriate choice. The graph of the prediction of energy production from natural gas for the next ten years is given below.

Graph 3.2. 10-year forecast of energy production from natural gas.



Graph 3.2. above shows the energy production from natural gas for ten years. it is observed from the analysis that energy production from natural gas for the next ten years fluctuates close to the previous years. This situation is given with numerical data in Table 3.4. below.

Table 3.4. 10-year forecast of energy production from natural gas.

Index	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
2023	30.237	22.773	37.245	19.572	40.552
2024	32.552	21.436	40.966	16.703	45.410
2025	30.840	18.071	39.683	12.939	45.324
2026	27.531	13.243	37.059	8.437	43.192
2027	27.947	12.390	38.404	7.875	45.269
2028	27.582	12.171	38.329	7.611	45.242
2029	26.533	11.474	36.717	7.322	44.129
2030	26.802	11.078	37.392	5.656	45.510
2031	27.092	11.105	38.582	6.427	45.536
2032	27.136	10.860	38.150	6.638	44.661

Table 3.4. presents the 10-year forecast of energy production from natural gas with numerical data, as it is observed that there is a fluctuating production; there is an increase between 2023-2024, followed by a decline, and energy production from natural gas shows a slight increase between 2031-2032.

4. Discussion and Conclusions

4.1 Dıscussion

The primary purpose of energy production is to meet the growing demand for energy to power homes, industries, transportation, and other human activities. Energy production generates usable energy from various sources such as fossil fuels, nuclear reactions, and renewable resources like solar, wind, hydro, geothermal, and biofuels. The energy production process involves converting the potential energy stored in these sources into usable energy, such as electricity or heat. However, the many ways that energy is produced have varied effects on the environment and make distinct contributions to climate change. Therefore, it is crucial to pursue sustainable and environmentally-friendly methods of energy production to ensure a secure and sustainable energy future for the planet. Oil and natural gas are fossil fuels tat are used worldwide for energy production. Oil is commonly used for transportation, heating, and electricity generation, while natural gas is mainly used for heating, cooking, and electricity generation. The energy production process from oil and natural gas involves extracting the resources from underground reservoirs, refining and processing them, and burning them to produce energy. However, the combustion of these fossil fuels releases carbon dioxide and other greenhouse gases into the atmosphere, contributing to climate change. Additionally, oil and natural gas extraction and transportation can have harmful environmental impacts, such as oil spills and leaks, land degradation, and water pollution. As the world shifts towards cleaner and more sustainable energy sources, attempts are made to reduce our reliance on fossil fuels and increase the use of renewable energy sources.

Iraq is a significant producer of oil and natural gas, with large reserves of these resources located primarily in the southern part of the country. The country's economy heavily relies on oil exports, which account for most of its revenue. In 2020, Iraq was the second-largest oil producer in OPEC, with an average production of around 3.6 million barrels per day. The country has also been increasing its natural gas production to meet its growing domestic demand for electricity. Despite its potential as a primary energy producer, Iraq faces several challenges in the sector, including a lack of investment in infrastructure and technology, political instability, corruption, and security issues. The country is addressing these challenges and attracting more foreign investment to its energy sector to realize its potential and contribute to its economic growth and development.

Several suggestions for avoiding fossil fuels are listed below:

- Transition to Renewable Energy Sources: Utilize renewable energy sources such as solar, wind, hydro, and geothermal power. Install solar panels at home or workplace to generate electricity or consider joining community solar projects. Explore options for purchasing renewable energy from local providers.

- Energy-Efficient Appliances: Choose energy-efficient appliances with high Energy Star ratings. Look for energy-saving features when purchasing electronics, lighting fixtures, and heating/cooling systems. Optimize energy consumption by turning off appliances when not in use and using power strips to avoid vampire power.
- Improve Home Insulation: Properly insulate your home to minimize energy loss. Insulate walls, roofs, and windows to reduce the need for heating and cooling. Use weatherstripping and caulk to seal gaps and prevent drafts. This reduces the reliance on fossil fuel-powered heating systems.
- Electric Transportation: Transition from conventional gasoline/diesel vehicles to electric vehicles (EVs) or hybrid vehicles. EVs produce zero tailpipe emissions and help reduce dependence on fossil fuels. If purchasing an EV is not feasible, consider carpooling, using public transportation, or biking/walking for shorter distances.
- Sustainable Commuting: Opt for eco-friendly commuting options like carpooling, ridesharing, or using public transportation. If available, consider using electric buses or trains that run on renewable energy sources. Encourage your workplace to provide incentives for employees who choose sustainable commuting options.
- Energy Conservation: Practice energy conservation in your daily life. Turn off lights, unplug electronics, and use natural light whenever possible. Set thermostats at energy-efficient levels and use programmable thermostats to optimize heating and cooling. Use energy-efficient light bulbs and appliances to reduce overall energy consumption.
- Support Renewable Energy Initiatives: Advocate for renewable energy by supporting organizations and policies that promote clean energy alternatives. Stay informed about renewable energy initiatives and participate in community programs or campaigns focused on renewable energy adoption.
- Choose Green Energy Providers: When possible, select energy providers that offer green energy options. Many utilities now provide renewable energy plans, allowing you to support clean energy generation through your electricity consumption.
- Educate and Raise Awareness: Share your knowledge about the benefits of renewable energy with friends, family, and colleagues.

Engage in discussions about climate change and the importance of transitioning away from fossil fuels. Encourage others to adopt sustainable energy practices in their own lives.

- Invest in Sustainable Businesses: Consider investing in companies that prioritize renewable energy and have sustainable practices. By supporting such businesses, you contribute to the growth and development of clean energy industries.

Finally, it is worth mentioning that every small step towards reducing fossil fuel consumption counts and collectively makes a significant impact on our planet's health and sustainability.

4.2. Conclusion

This study used Structured Neural Networks to make a 10-year forecast of Iraq's energy production from oil and natural gas. As a result of the analysis, it is observed that energy production from both oil and natural gas is similar to previous years. The production of energy from oil and natural gas has several harmful impacts on the environment and human health. Oil and natural gas extraction involves drilling, fracking, and other methods that can cause soil and water pollution, habitat destruction, and even earthquakes. The transportation and storage of oil and natural gas can also lead to spills and leaks, contaminating soil and water sources and harming wildlife. Burning these fossil fuels for energy releases greenhouse gases into the atmosphere, contributing to climate change, which has far-reaching and severe impacts on the planet's ecosystems and human societies.

It is not sustainable to continue producing energy just from natural gas and oil.

It is not sustainable to continue producing energy just from natural gas and oil. It poses significant risks to the planet and its inhabitants, highlighting the urgent need of transition towards cleaner and more sustainable energy sources. Additionally, the production and use of fossil fuels have been linked to various health issues, including respiratory problems, cancer, and other diseases.

This study suggests that energy production from oil, which is harmful to nature, should be reduced, and Iraq should focus on renewable energy production. One proposal to reduce energy production from oil is to accelerate the transition to renewable energy sources such as solar, wind, geothermal, and hydropower. This can be achieved through various means, including investment in research and development to improve the efficiency and affordability of renewable technologies, implementing policies and incentives that encourage the deployment of renewable energy systems, and establishing public-private partnerships to support the transition to cleaner energy. Further, another approach is to promote energy conservation and efficiency measures, such as improving building insulation and using more fuel-efficient vehicles, which can help reduce the demand for oil and other fossil fuels. Finally, some advocate for policies that discourage the production and consumption of fossil fuels, such as imposing a carbon tax or phasing out subsidies for the oil and gas industry. By reducing our reliance on oil for energy, we can reduce our environmental impact, mitigate the risks of climate change, and create a more sustainable energy future.

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پێشبینیکردنی بەرهەمهێنانی وزە لە نەوت و گازی سروشتی بە تۆڕی دەماری دەستکرد: نموونەی عێراق

پوختە

وزە پێویستییەکی گرنگە بۆ ژیانی مرۆڤ. ژیانی مرۆڤ گەشەسەندنێکی لەسەر بنەمای وزە نیشان دەدات. پێداویستی وزەی کۆمەڵگا گەشەسەندووەکان بە هۆکاری دیمۆگرافی، کۆمەڵایەتی و ئابووری بەردەوام لە زیادبووندایە. هەموو کۆمەڵگایەک هەوڵ دەدات بە بەکارهێنانی چەند سەرچاوەیەکی دیاریکراو ئەم پێویستی وزەیە پڕ بکاتەوە. عێراق پێداویستییە گەشەسەندووەکانی بۆ وزە بەزۆری لە نەوت و گازی سروشتییەوە دابین دەکات. لە م توێژینە وە یە دا خەملاندن بۆ بڕی ئە و وزە یە ی عێراق بۆ ماوە ی ١٠ ساڵ لە نە وت و گازی سروشتی بە ر ھە مدە ھێنرێت دەکرێت بە بەکارھێنانی مۆدێلی تۆڕی دە ماری دە ست کە لە زۆر بواردا بە کاردە ھێنرێت بە ھۆی ئە وە ی توانای خە ملاندنی بە رزی ھە یە بڕی وزەی بەرهەمهێنراو لە گازی سروشتی و نەوت لە عێراق لەنێوان ساڵانی ١٩٧٢ و ٢٠٢٢ وەک داتای ساڵانە وەرگیراوە پاش ڕاهێنانی داتاکان، کێشەکانی کەمترین پەراوێزی هەڵە دیاری کران و خەملاندنەکە ئەنجامدرا. بە بەکارهێنانی تۆڕی دەماری دەستکرد، خەملاندنێکی ١٠ ساڵەی بەرهەمهێنانی وزە بە جیا بۆ نەوت و گازی سروشتی ئەنجامدرا. چاوە ڕوان دە کرێت عێراق بە ر ھە م بێنێت

وشە کلیلییەکان: گازی سروشتی، نەوت، تۆڕی دەماری دەستکرد

التنبؤ بإنتاج الطاقة من النفط والغاز الطبيعي باستخدام الشبكات العصبية الاصطناعية: مثال العراق

ملخص

الطاقة ضرورة لا غنى عنها لحياة الإنسان. تظهر حياة الإنسان تطورا قائما على الطاقة. تميل احتياجات المجتمعات النامية من الطاقة إلى الزيادة باستمرار لأسباب ديموغرافية واجتماعية واقتصادية. يحاول كل مجتمع تلبية هذه الحاجة المتزايدة للطاقة باستخدام موارد معينة. يلبي العراق احتياجاته المتزايدة من الطاقة في الغالب من النفط والغاز الطبيعي. في هذه الدراسة تم تقدير كمية الطاقة التي سينتجها العراق من النفط والغاز الطبيعي لمدة عشر سنوات باستخدام نموذج الشبكة العصبية الاصطناعية الذي يستخدم في العديد من المجالات لأنه يتمتع بمهارات تقدير عالية. تم أخذ كمية الطاقة المنتجة من الغاز الطبيعي والنفط في العراق بين عامي ١٩٧٢ و ٢٠٢٢ كبيانات سنوية. بعد تدريب البيانات ، تم تحديد الأوزان ذات أقل هامش خطأ ، وتم إجراء التقدير. باستخدام الشبكة العصبية الاصطناعية ، تم إجراء تقدير لإنتاج الطاقة لمدة ١٠ سنوات بشكل منفصل للنفط والغاز الطبيعي. من المتوقع أن ينتج العراق

الكلمات المفتاحية: الغاز الطبيعي ، النفط ، الشبكة العصبية الاصطناعية