Cuadernos de Economía (2024) Volume 47, Issue 135, 55-64

Asociación Cuadernos de economía

Cuadernos de economía

www.cude.es

ARTÍCULO

Global Energy Crisis: Evidence From Egypt Using Neural Network

Mohammed Galal Abdallah Mostafa[1]*, Mohammed Ahamed Mohamed Mater[2], Eman Ahmed Ahmed Awad[3], Mohamed Maher[4], Mahmoud Ibrahim Mansour Gomaa[5], Mousa Gowfal Selmey[6], Nabil Medhat Arafat Mahmoud[7], Neveen Mohsen Ahamed Zaki[8]

[1]Economic Department, Faculty of Commerce, Mansoura University, Egypt.
Email: drmohammed20082008@gmail.com, ORCID iD: https://orcid.org/0000-0002-9115-5619
[2]Economic Department, Faculty of Commerce, Mansoura University, Egypt.
Email: prof_mater2006@mans.edu.eg, ORCID iD: https://orcid.org/0000-0002-6170-8593
[3]Economic Department, Nile Higher Institute for Commercial Science and Computer Technology, Egypt.
Email: dr.Eman@nilehi.edu.eg, ORCID iD: https://orcid.org/0009-0001-5535-1161
[4]Economic Department, Faculty of Commerce, Mansoura University, Egypt.
Email: mohamed_maher16961737@mans.edu.eg, ORCID iD: https://orcid.org/0000-0002-9825-5276
[5]Economic Department, Faculty of Commerce, Mansoura University, Egypt.
Email: drmohammed2008@yahoo.com, ORCID iD: https://orcid.org/0000-0001-9111-5612
[6]Economic Department, Faculty of Commerce, Mansoura University, Egypt.
Email: mousa_gowefal@gmail.com, ORCID iD: https://orcid.org/0000-0002-9115-5213
[7]Applied Statistics and insurance Department, Faculty of Commerce, Mansoura University, Egypt.
Email: nabil_arafat@mans.edu.eg, ORCID iD: https://orcid.org/0000-0003-3282-9385
[8]Applied Statistics and insurance Department, Faculty of Commerce, Mansoura University, Egypt.
Email: neven_mohsen@mans.edu.eg, ORCID iD: https://orcid.org/0000-0002-0930-0195

Corresponding author: Email: drmohammed20082008@gmail.com

Jel Codes:

C49, Q49

Keywords:

Energy Crisis; causes; Egypt; neural network, Energy Crisis, Neural Network Analysis, Renewable Energy, Hydrogen and Electric Vehicles.

Abstract: The paper will discuss the energy crisis within the framework of international geopolitics and its particular consequences on the Arab Republic of Egypt between 2000-2022. It examines the most critical aspects that led to the challenges in energy in Egypt and evaluates their socio-economic outcomes. The research uses the methodology of the neural network to list and prioritize the main factors that lead to the energy crisis in Egypt. It was found that the most notable factors are the increased prices of energy in the world and high rate of population growth, which causes significant pressure on the national energy supply. Secondary factors encompass an increased inflation and exportation of energy resources that increase the domestic shortage. Meanwhile, the impact of other variables, including urbanization and the general economic growth, turned out to be insignificant on the crisis. The paper indicates the impact of such factors such as pressure on the existing services, higher energy prices, and possible derailments of sustainable development targets. The study gives strategic recommendations on how to mitigate the crisis and improve the energy security based on these findings. The most important of these recommendations is to encourage the investment in renewable sources of energy and especially in hydrogen energy as one of the promising sources. Also, the paper suggests the creation and introduction of the strategies aimed at localizing the manufacturing of electric vehicles in Egypt in order to decrease the reliance on imported energy and promote technological innovation in the local market. This study provides useful information to policymakers, energy planners, and other interested parties facing the Egyptian energy problems within the international environment that is changing.

Submission: 22-02-2024
Acceptance: 28-05-2024
Publication: 30-05-2024

Author Correspondence: drmohammed20082008@gmail.com

https://doi.org/10.32826/cude.v47i135.1508

1. Introduction

The energy and fuel crisis is one of the crises that has worsened with the Russian war. At the beginning of the 21st century, the world began to move towards clean energy to reduce carbon emissions that cause global warming and climate change. Most countries in the world therefore took policies and measures to reduce the excessive use of oil and petroleum in power generation. With the outbreak of the Russian-Ukrainian war, the energy and fuel crises worsened. Russia is a major player in the global energy markets. It is one of the top three producers of crude oil in the world, competing for the lead with Saudi Arabia and the United States. Russia is heavily dependent on oil and natural gas revenues, which accounted for 45% of the Russian federal budget in 2021. Russia is also the world's largest producer of natural gas in 2021, as shown in Figure 1.

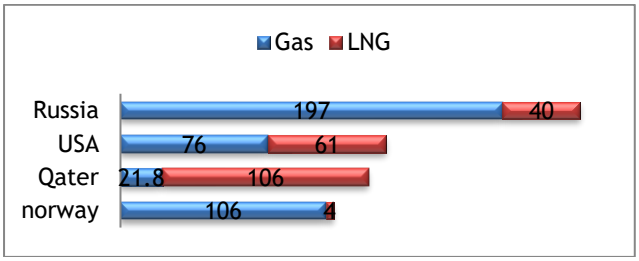

Figure 1: Leading gas exporting countries in 2020 by type of export (billion cubic meters).
Source: authors according to Niyazova (2025) data

Russia is the world's largest gas exporter, having exported 197.2 billion cubic meters of gas via pipelines in 2020 and 40.4 billion cubic meters of liquefied natural gas. The United States was the second-largest natural gas exporter in the world, followed by Qatar and Norway (Elhelaly & Algarhy, 2024). Therefore, imposing any sanctions on Russia is likely to cause a global gas crisis due to Russia's dominant share of the market. In addition, the European Union and the United Kingdom are both heavily reliant on Russia for natural gas imports. Figure 2 shows the percentage of natural gas imports from Russia for the European Union and the United Kingdom. This makes Russia a key player in the global gas market. Any disruptions to Russian gas exports could have a significant impact on global energy prices and security (Okafor, Adusei, & Edo, 2024).

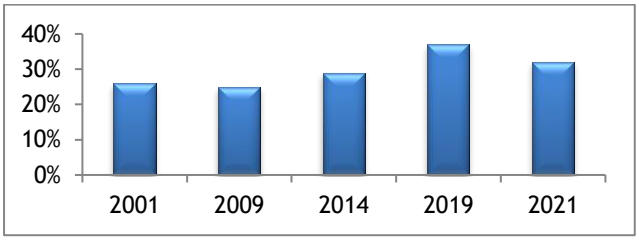

Figure 2: Russia's share of European Union and United Kingdom gas demand in the period 2001-2021.
Source: authors according to Smirnov & Bulgakov (2022).

The figure above shows the extent to which the European Union and the United Kingdom rely on Russian gas. Since 2001, when it represented 26% of its gas needs from Russia, it has continued to rise, reaching 37% in 2019 and falling to 32% in 2021. This makes the European Union's reliance on Russian gas a pressing matter, which is what led Russia to link the sale of Russian gas and oil to the ruble instead of the dollar to increase demand for the Russian currency, which has deteriorated due to sanctions resulting from the Russian-Ukrainian war. The rise in gas and fuel prices has exacerbated the global energy crisis. The world still relies on extractive industries to generate power, and oil and gas still account for the largest share of power generation. The European Union relies on 20% of gas for power generation, and therefore a shortage of gas supplies due to the Russian war will lead to an exacerbation of the severity of the global energy crisis (Ning et al., 2023).

Russia also has a vast network of pipelines for exporting gas, through transit routes through Belarus and Ukraine and through pipelines that send gas directly to Europe (including the Nord Stream, Blue Stream, and Turk Stream pipelines). Russia completed work on the Nord Stream 2 pipeline in 2021, but the German government decided not to approve certification in the wake of the Russian invasion of Ukraine. Russian natural gas accounted for 45% of imports and about 40% of the European Union's gas demand in 2021. This share has increased in recent years as domestic natural gas production in Europe has declined. Germany, Turkey, and Italy are the largest importers of Russian natural gas (Saadh, 2022; Sanganeria, 2025).

In addition, Russia is working to expand its capacity to produce liquefied natural gas (LNG) to compete with the growing LNG exports from the United States, Australia, and Qatar. In 2021, the government issued a long-term development plan for LNG, targeting exports of 110-190 billion cubic meters per year of LNG by 2025. In 2021, Russia exported 40 billion cubic meters of LNG, making it the fourth-largest LNG exporter in the world and about 8% of the global LNG supply. These fuels are the primary energy sources that countries rely on, so any shortage in the supply chains of primary energy (gas, coal, and oil) will pose a threat to global energy, (Nguyen & Le, 2024).

The war in Ukraine has highlighted the importance of energy security for the European Union. The EU is now committed to reducing its reliance on Russian gas and investing in renewable energy sources. This will help to reduce the EU's vulnerability to shocks in the global energy market and create a more sustainable energy future (Ozyesil & Tembelo, 2025).

This paper aims to identify the causes and solutions to the global energy crisis, with a specific focus on proposing mechanisms for addressing it within Egypt. To achieve this goal, the paper is divided into the following sections: I. Ways to address the global energy crisis; II. Mechanisms for Addressing the Global Energy Crisis in Egypt; III. Conclusion.

2. Methodology

2.1 Ways to address the global energy crisis:

The global community needs to work together to address the underlying causes of the crisis, such as the reliance on fossil fuels and the growing demand for energy. Specific actions that can be taken to address the underlying causes of the global energy crisis include: (1) investing in renewable energy: governments and businesses can invest in renewable energy sources, such as solar and wind power, which are more sustainable than fossil fuels. (2) Promoting energy efficiency: Governments can promote energy efficiency measures, such as insulation and energy-efficient appliances, to reduce the

amount of energy needed to power our homes and businesses. (3) Reducing demand for energy: Governments can encourage people to reduce their energy consumption by walking, biking, or taking public transportation instead of driving, and by turning off lights and appliances when they are not in use. By taking these actions, the global community can help build a more sustainable future and reduce the risk of future energy crises (Ampe et al., 2021).

There are also some external measures to address the energy crisis. International organizations have imposed a set of international sanctions on Russia to stop the war. As a result, Russia became the most sanctioned country in the world in just a few days, as shown in Figure 3. Some countries in Asia have taken tough measures against Moscow, while China has refused to categorically condemn the invasion of Ukraine and has imposed no sanctions on Russia. India, Pakistan, Vietnam, Bangladesh, Sri Lanka, Laos, and Mongolia voted in favor of a United Nations resolution calling for an end to Russia's military operations in Ukraine. Meanwhile, Western allies such as Australia, Japan, South Korea, and Taiwan have imposed sanctions. Tokyo and Seoul have excluded some Russian banks from the global Swift payment system, which has not had the desired impact. This is because the Asian countries that have joined the Western-led sanctions only account for 8% of Russia's global trade (Elhelaly & Algarhy, 2024).

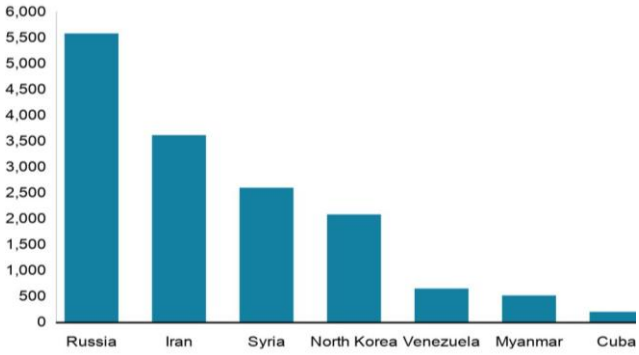

Figure 3: The most sanctioned countries of the international system, 2022.
Source: Jones & Portela (2020).

The sanctions imposed on Russia have had a significant impact on the global energy market. They have led to a sharp increase in energy prices, which has had a negative impact on the global economy. The sanctions have also disrupted the supply of energy from Russia, which has exacerbated the global energy crisis. The following are some of the key effects of the sanctions on Russia: (1) A sharp increase in energy prices: The sanctions have led to a sharp increase in energy prices, which has had a negative impact on the global economy. For example, the price of Brent crude oil has increased by more than 50% since the beginning of the war in Ukraine. (2) Disruptions to the supply of energy: The sanctions have disrupted the supply of energy from Russia, which has exacerbated the global energy crisis. For example, Russia has reduced its gas exports to Europe by about 30%. (3) A decline in Russia's economy: The sanctions have led to a decline in Russia's economy. The International Monetary Fund has forecast that Russia's economy will contract by 8.5% in 2022 (Fu, Lu, & Pirabi, 2024).

Generally, the outbreak of the Russian-Ukrainian war had a significant impact on the global energy market. The war led to a sharp rise in oil and natural gas prices, as well as a decline in supply. This was due to several factors, including (1) sanctions imposed on Russia by the United States and its allies. These sanctions have limited Russia's ability to export oil and natural gas, which has reduced global supply. (2) Fears of a disruption in Russian energy supplies. These fears have led to increased demand for oil and natural gas from other producers, which has also contributed to higher prices. The sanctions are likely to continue to have a significant impact on the global energy market for the foreseeable future. They are likely to lead to higher energy prices and increased uncertainty in the global energy market (Gianfrate & Peri, 2019).

Countries have taken some policies and mechanisms to address the global energy crisis by looking for safer energy alternatives. The green transition has been an important factor in recent times to move towards a more environmentally friendly green economy, which has become essential in light of international changes. The percentage of renewable and clean energy in power generation is weak compared to oil, natural gas, and coal. This is what led the countries, led by the United States of America, to take crisis measures for the green transition and urge research centers to provide solutions and proposals for green energy. By 2050, reaching net zero carbon emissions will cost an additional 9.2$ trillion annually. The total global spending by governments, businesses, and individuals on energy and land use systems will need to increase by 9.2$ trillion annually if the world wants to reach net zero by 2050 (Bloomberg., 2022). This increase is equivalent to 60% of the level of global investment today and is equal to half of global corporate profits, a quarter of global tax revenues, and 7% of household spending. An additional $1 trillion of assets from high-emissions assets will also need to be reallocated to low-carbon assets (Kumar et al., 2024).

The cost of the world reaching net zero carbon may be impossible at the current time, but green investments and bonds have increased in recent times to mitigate the severity of climate change and reduce the crises resulting from the energy crisis. For the United States, achieving net zero emissions by 2050- a central goal of the climate plan of President-elect Joe Biden - will require expanding renewable energy systems, building more efficient homes, and operating 50 million electric vehicles. How can the United States transition to an energy system that meets scientific guidance to keep the climate habitable? Despite the initial costs being high, switching to cheaper electricity and creating up to one million new jobs will more than offset them. The rush by countries to produce electric vehicles and encourage their use is a major step in the field of the green transition (Wang & Zhang, 2022). Figure 4 shows the leading countries in electric vehicle production in 2020.

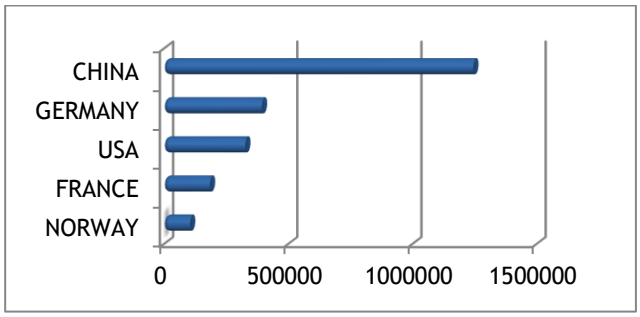

Figure 4: Countries with the largest markets for electric cars.
Source: Flammer (2021).

With the rise of Tesla's stock market in 2020 and the announcement of new electric vehicle goals by many

countries and automakers, electric vehicles have come to the international spotlight, both in terms of production, consumption, and the regulatory framework that supports their spread (Ye & Zhang, 2024). While they still account for only 9% of global passenger car sales, many countries, especially across Europe, have taken significant steps towards a cleaner future in 2022. The International Energy Agency summarizes how goals, announcements, and the introduction of new models have contributed to the perception that electric vehicles are the future of transportation while also cautioning that the concurrent increase in global SUV sales has offset a large portion of the emissions savings of electric vehicles (Shang et al., 2020). China experienced a breakout year in 2021, with electric vehicle sales nearly tripling from 1.2 million to 3.4 million. Europe remains the second-largest electric vehicle market, with new registrations increasing by nearly 70% to reach 2.3 million, nearly half of which are plug-in hybrids. In the United States, sales exceeded half a million for the first time, but the overall market share of electric vehicles remains much lower than that of China and many European markets. The growth of the global electric vehicle market is expected to continue in the coming years. The International Energy Agency forecasts that electric vehicles will account for 30% of global passenger car sales by 2030 (Gonzalez-Salazar, Kormazos, & Jienwatcharamongkhol, 2023).

2.2 Mechanisms for Addressing the Global Energy Crisis in Egypt

Since 2007, Egypt has witnessed a large gap between available energy and demand. This crisis worsened and affected economic performance, reaching its peak in 2014, which led to frequent power and electricity outages, which negatively affected the performance of economic sectors, in addition to distortions in energy pricing that continued for many years. excessive consumption and not searching for renewable alternatives (Bai, 2025).

What exacerbated the crisis in Egypt was the increase in financial dues to foreign companies operating in the petroleum sector. Figure 5 shows the development of financial dues to foreign companies operating inside Egypt, that is, the development of the government's debts towards companies in foreign countries, which was exacerbating the crisis. However, since 2015 and since the launch of Egypt's Vision 2030, the Egyptian government has intended to confront this crisis and advance the energy sector at all levels, by restructuring energy support and achieving technical sustainability by developing renewable energy programs and rationalizing Energy and intensifying maintenance, in addition to establishing and developing the necessary legal frameworks, to advance the sector through the establishment of a gas facility regulatory body, reviewing the relevant structures and frameworks in all petroleum and electricity facilities, and creating a mechanism for integrated central planning for the energy sector, which led to a reduction in the debts owed by The government gradually reached its complete end.

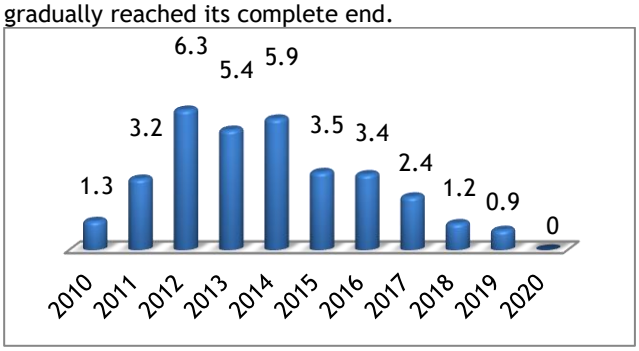

Figure 5: Evolution of foreign oil companies' receivables at Egypt during 2010-2020 (billion dollars).
Source: the authors according to Ministry of Petroleum and Mineral data.

2.3 The causes of the energy crisis in Egypt

We investigate the determinants of energy crisis in Egypt using an artificial neural network model.

An Artificial Neural Network (ANN) is a model that constructs a new structural system to simulate the biological nervous system in the human body for information processing. This connects organizes several of the processing elements, which are neurons, so that they can work together to solve the phenomenon being studied (Huo et al., 2025).

Neural networks are used because, unlike other methods, they don't require any preconditions or assumptions, and they're separated from the competition by their high flexibility and capacity to produce acceptable solutions. It was used in this study because it arranges the independent variables according to the importance of their effect on the dependent variable, which is exactly what the researcher wants to know to understand the factors that influence energy consumption.

The ANN model employed in the study is shown in Equation No. (4), which has the following form Khan, Arora, & Meena (2025):

$$Y_t = F\,[H_1\,X_{t-1},\ H_2\,X_{t-2},\ \ldots,\ H_N\,X_{T-N})] + U \qquad (4)$$

Y_t: output layer and represents the dependent variable, expressing economic growth.

X_1…, X_N: input layer and represents explanatory variables or independent variables.

F, H: function of neural network

H: represents Hidden Layer Activation Function

F: represents the output of Hidden Activation Function

U: Error Term.

3. Results

Table 1 contains the variables and data sources. The dependent variable is Energy consumption, which is abbreviated throughout the rest of the study (EC). Seven variables are considered independent variables when it comes to determining energy consumption.

Table 1: Independent Variables.

Variable	Symbol	Source
WORLD OIL PRICE	OPRICE	The Global economy database
Trade openness	OPPENSS	The Global economy database
Population Growth rate	PGROWTHE	The Global economy database
URBANIZATION	URBAN	UNCTAD database
INDUSTRY GROWTH RATE	INDUSTRY	The Global economy database.
Inflation	INF	The Global economy database.
ECONOMIC Growth	GDP	The Global economy database
RENEWABLE ENERGY PRODUCTION	REP	The Global economy database

ENERGY IMPORTS	EI	The Global economy database
Exchange rate	EX	UNCTAD database

Source: The author

A program SPSS ver. (22) was used to determine the neural network architecture and know the determinants of energy consumption in EGYPT. There are three layers in the neural network shown in Table 2. The input layer, which represents the independent variables, is the first layer which consists of seven variables. The hidden layer, which consists of one neuron, is the second layer. The output layer, which is represented by the dependent variable, energy consumption (Ec), is the third layer as shown in Table 2.

Table 2: Network Information.

Input Layer	Covariates	1	OPRICE
		2	OPPENSS
		3	PGROWTHE
		4	URBAN
		5	INDUSTRY
		6	INF
		7	GDP
		8	REP
		9	EI
		10	EX
Hidden Layer(s)	Number of Units[a]		22
	Rescaling Method for Covariates		None
	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1[a]		7
	Activation Function		Hyperbolic tangent
Output Layer	Dependent Variables	1	EC
	Number of Units		1
	Rescaling Method for Scale Dependents		Standardized
	Activation Function		Identity
	Error Function		Sum of Squares

a. Excluding the bias unit

Source: Spss v.22 output

It is clear from Tables 3 and 4 that the number of time periods in the network training phase is (15), representing (68.18%) of the total data. It is also clear from the table that the sum of squares of error in the training phase was (0.358) and the relative error was (0.082), while in the testing phase the sum of squares of error was (0.042) and the relative error was (0.022), using the multi-layer network. Multilayer Perceptron (MLP). There is no doubt that the low value of the relative error indicates the accuracy and quality of the model.

Table 3: Case Processing Summary.

		N	Percent
Sample	Training	15	68.18%
	Testing	7	31.82%
Valid		22	100.0%
Excluded		0	
Total		19	

Source: Spss v.22 output

Table 4: Model Summary.

Training	Sum of Squares Error	.358
	Relative Error	.082
	Stopping Rule Used	1 consecutive step(s) with no decrease in error[a]
	Training Time	00:00:00.006
Testing	Sum of Squares Error	.042
	Relative Error	.022

Dependent Variable: EC, a. Error computations are based on the testing sample.

Source: Spss v.22 output

Table 5 shows the relative importance of the independent variables in the neural network model used to find out the causes of the energy crisis in Egypt. It is clear from the table that the factors determining economic growth in these countries are as follows:

1. International energy prices, as its relative importance in the occurrence of the energy crisis in Egypt amounted to about (0.312) with a standard value of 100%, Followed by an increase in the exchange rate of the dollar against the pound, reaching approximately 0.29 with a standard value of 90%.
2. Population increases, high inflation rate, and energy exports abroad, as their relative importance in the occurrence of the energy crisis in Egypt amounted to about (0.404).

Table 5: Independent Variable Importance.

Variable	Importance	Normalized Importance
OPRICE	.312	100.0%
OPPENSS	.107	0.4%
PGROWTHE	.117	75.1%
URBAN	.001	7.3%
INDUSTRY	.003	.5%

INF	.180	.1%
GDP	.008	2.0%
REP	.000	6.4%
EX	.290	90%
EI	.000	1.8%

Source: Spss v.22 output

3.1 Ways to confront the energy crisis in Egypt

Egypt has taken crisis measures to deal with the crisis, whether at the local level through internal measures or at the international level by enhancing energy security, demarcating maritime and land borders to enhance primary sources, and building partnerships regarding investment in clean energy (Flottmann et al., 2025).

3.1.1 Securing and enhancing primary energy sources:

Large reserves of gas have been made available, and self-sufficiency has been achieved. Natural gas exports amounted to 6,724 million cubic tons in 2019, the value of gas exports amounted to $1,147 million, and the volume of exports increased to 8 million cubic tons in 2022, but there is noticeable progress in the volume of exports. During previous years, as shown in Figure 6.

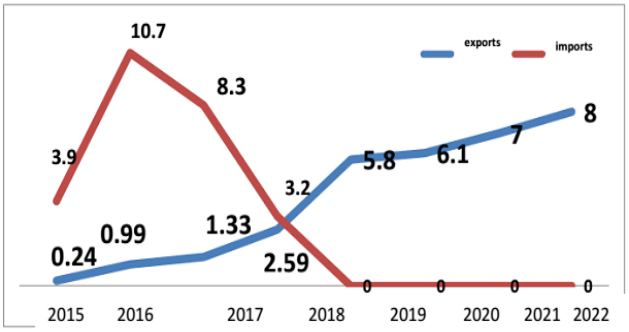

Figure 6: Volume of gas exports and imports during the period 2015 – 2022 (million cubic meters).
Source: Prepared by the authors based on data from the Statistical Review of World Energy

The Figure 6 and 7 show that the global trade in gas has been growing in recent years. This is due to several factors, including the increasing demand for gas for power generation, industrial use, and heating. In 2019, Egypt's gas exports doubled compared to the previous year, 2018, and imports fell to 0% in both 2019 and 2020. As a result of stopping imports, Egypt saved $1.5 billion, and the trade deficit fell by 79.5%. Egypt also resumed exporting natural gas to Jordan via the Arab Gas Pipeline, with exports reaching about 53 billion cubic feet in 2019. In addition, Egypt exported about 172.8 billion cubic feet of liquefied natural gas from its liquefaction plants (the Edco plant) in 2019 through 45 LNG shipments. This was due to increased production and new discoveries. In late 2018, the Egyptian Natural Gas Holding Company (EGAS) announced that it had achieved self-sufficiency, and thus it stopped importing liquefied natural gas. This has strengthened Egypt's competitiveness in the gas sector due to self-sufficiency and increased production. Emerging markets have also relied on LNG from the Damietta complex, as shown in Figure 8. This figure shows the volume of LNG exports from the Damietta station. In addition, Egypt's gas exports have doubled, and the share of gas exports to countries participating in the sanctions against Russia has increased.

3.2 The increase in Egypt's gas exports is due to several factors, including:

- Increased production: Egypt has made significant discoveries of natural gas in recent years, which has led to increased production.
- Reduced imports: Egypt stopped importing liquefied natural gas in late 2018, which has freed up more gas for export.
- Demand: The global demand for natural gas is growing, which has created new opportunities for Egypt to export gas.

3.3 The increase in Egypt's gas exports has several benefits, including:

- Increased revenue: Egypt is earning more revenue from gas exports, which is helping to improve the country's economy.
- Reduced reliance on imports: Egypt is becoming less reliant on imports of natural gas, which is reducing the country's vulnerability to price shocks.
- Increased geopolitical influence: Egypt is becoming a more important player in the global energy market, which is giving the country more geopolitical influence.

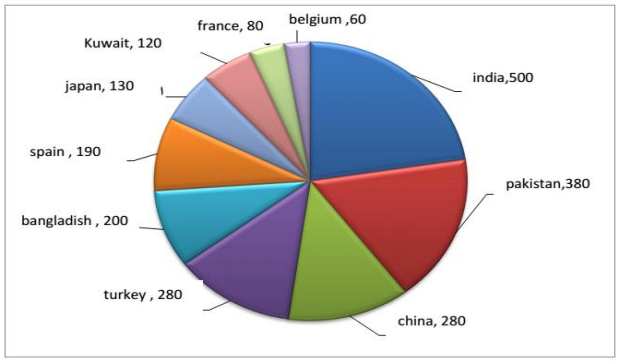

Figure 7: LNG importing markets from Damietta station 2021(thousand tons).
Source: authors based on the OPEC report 2022

Figure 8 shows Egypt's natural gas exports. Most of Egypt's liquefied natural gas went to countries in the Asia-Pacific region, with Pakistan, China, and Taiwan as the top three importers. The United Kingdom also imported about 6 billion cubic feet, or 10% of Egypt's total exports, in 2021.

3.4 The increase in LNG exports to these markets is due to several factors, including:

- The growing demand for LNG in Europe: The European Union is seeking to reduce its reliance on Russian gas, which has led to an increase in demand for LNG from other sources.
- The proximity of Damietta station to European markets: Damietta station is located in the Mediterranean Sea, which makes it easily accessible to European markets.
- The competitive prices of Egyptian LNG: Egyptian LNG is relatively competitive in terms of price, which has made it an attractive option for European buyers.

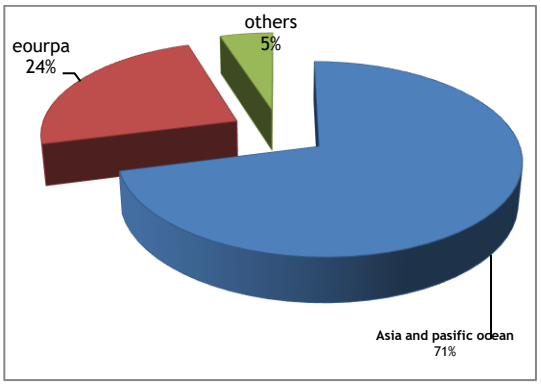

Figure 8: Egypt's natural gas exports to the world in 2022. **Source**: Prepared by the Authors based on the OPEC report 2022

The previous figure shows the extent of the European Union's reliance on Egyptian gas, which led to the establishment of a new partnership with the European Union in 2023. As the European Union moves away from Russian gas supplies, Russia is "not a reliable energy partner for the European Union, as it has repeatedly tried to manipulate the European Union's energy markets and use energy as a source of blackmail."

The partnership between Egypt and the European Union in the field of gas is based on the following principles:

- Security of supply: The partnership aims to ensure the security of gas supplies for both Egypt and the European Union.
- Economic cooperation: The partnership aims to promote economic cooperation between the two sides, including the development of new gas fields and the construction of new infrastructure.
- Climate change: The partnership aims to promote the transition to clean energy, including the development of renewable energy sources.

The partnership is expected to play an important role in helping the European Union reduce its reliance on Russian gas. It is also expected to boost the Egyptian economy and create new jobs.

4. Discussion

4.1 Increasing the contribution of gas in power generation

The second policy to address the energy crisis in Egypt is to increase the contribution of gas to power generation. Gas is a relatively clean and efficient fuel, and it is abundant in Egypt. Over the past twenty years, power generation has been the most important driver of gas consumption demand in Egypt. It is the largest consumer of gas in the region, with a natural gas consumption of 1,314 billion cubic feet (3,600 million standard cubic feet per day). Gas remains the most important source for power generation worldwide. The global proportion of gas contribution to world power generation reached 23.5% of totally different sources in 2019, making it the second after coal (Alsmadi et al., 2023).

In Egypt, the share of gas from electricity generation reached about 60% of total energy sources in 2020. In addition to reducing the proportion of coal and oil use and relying on natural gas as a clean source of energy with the lowest carbon emissions, natural gas will play a major role in the future energy transformation, which will enhance the position of renewable energy sources in climate protection. Renewable energy needs other energy sources with suitable environmental impacts. The reserve ratio of the total world volume reached 1.06% in 2015, reaching 1.08% in 2019. 4.14% of the OPEC countries' share and 4.04% of the total Arab reserve. Despite the small size of Egypt's contribution to the total, it represented the largest percentage (47%) of Arab liquefied natural gas growth. This increase in the annual growth of the gas sector gives Egypt an opportunity in the coming period to achieve development in the sector. Egypt has a long history of stable relations with the European Union. This gives Egypt a relative advantage in exporting liquefied natural gas to the European Union as a substitute for Russian gas and benefiting from rising prices. In this way, Egypt can turn the energy crisis and gas supply shortage into an opportunity to maximize its imports and strengthen its relationship with the European Union.

4.2 To increase the contribution of gas in power generation, Egypt can take the following steps:

- Invest in new gas-fired power plants: Egypt can invest in new gas-fired power plants to increase the country's electricity generation capacity.
- Convert existing coal-fired power plants to gas-fired power plants: Egypt can convert existing coal-fired power plants to gas-fired power plants to reduce emissions.
- Promote the use of gas-fired cogeneration. Gas-fired cogeneration is a process that produces both electricity and heat from the same fuel source. This can help improve efficiency and reduce emissions.

4.3 Expansion of renewable energy production:

Egypt has set a strategy to increase the share of energy generated from renewable energy to 20% of the total maximum load in Egypt in 2022 and 42% by 2035 of the total generated energy.

It is worth noting that in 2020, Egypt's development assistance amounted to 9.8 billion US dollars, which was distributed over several projects to achieve the Sustainable Development Goals. The seventh goal related to clean energy accounted for 23.2% of total development assistance, which is equivalent to 5.9 billion dollars (the annual report of the New and Renewable Energy Authority, 2021). In fact, 20% of electricity was produced from renewable energy in 2022.

4.4 Localizing the production of electric vehicles:

Egypt has sought to enact laws related to the localization of the production of electric vehicles, which is a stage in the transition to new and renewable energy. Based on Egypt's vision 2035, decision number 419 of 2018 was issued to exempt electric vehicles from customs duties. The Ministry of Industry and Trade also issued decision number 255 of 2018 to regulate the import of used electric vehicles. The file of electric vehicle production was also assigned to the Ministry of Military Production, which in turn announced a strategy for the use and localization of electric vehicles by 2040 in collaboration with China. The most important axes of this strategy were as follows (Zhu, 2025).

- Localizing domestic manufacturing.
- Possessing the technology for manufacturing electric vehicles at a rate of 65% by 2030.
- Establishing public and private charging units.
- Replacing outdated vehicles that have been in use for more than 20 years.

The delivery of the file of electric vehicle production and related to new and renewable energy to the Ministry of Military Production is the best choice in crisis

management, given the ability of military institutions to face internal and external crises. This is what the United States is doing, as we mentioned before, regarding the crisis of solar panels and others.

4.5 Tax incentives for renewable energy in Egypt:

In order to attract more energy investments in the energy sector (including the renewable energy sector) in the country, Egypt adopted in 2015 a fundamental amendment to its investment law since 1997. The incentives include reducing the sales tax to 5% from 10% and setting the customs duties on equipment used in production at 2%. In addition to reducing the renewable energy customs duty for renewable equipment by 2% on new and renewable energy equipment in customs (Wang, Xiong, & Mohsin, 2024).

4.6 External measures to transform Egypt into a central energy hub.

The Arab Republic of Egypt has formulated its orientations and objectives through the Sustainable Development Strategy 2035 for the Egyptian electricity sector to make Egypt a central energy hub. The Egyptian electricity sector is seeking to develop its performance in diversifying the sources of electrical energy and to achieve its economic goals. The Egyptian Electricity Holding Company is adopting new policies based on energy trade at the regional and international levels through electric interconnection with neighboring countries and its membership in various energy groupings at the continental level up to the international level through its relentless pursuit of its membership in international electric interconnection organizations (Shah, Murodova, & Khan, 2024).

4.7 Expansion of the issuance of green bonds:

Egypt is seeking to transition to a green economy by activating the enactment of legislative and financial laws to accelerate the transition to sustainable energy. Indeed, Egypt, as the first country in the Middle East and North Africa, issued sovereign green bonds in the global markets, worth $750 million for a term of 5 years. In the meantime, the total value of purchase orders for the issuance of sovereign green bonds reached more than $3.7 billion, which helped to reduce the yield to 5.25% instead of 5.75%. Of the proceeds from the green issue allocated to financing of the green issue, 46% was allocated to clean transportation projects, and 54% to sustainable water and sanitation projects, in a way that contributes to creating new job opportunities and reducing harmful emissions to the environment (Negi, Jaiswal, & Rekunenko, 2025).

4.8 Investment in green hydrogen

Green hydrogen is considered one of the most important sources of clean energy in recent times, due to its lightness and high reactivity. Many countries have announced plans to invest in the production of green hydrogen. Based on this, Egypt announced a comprehensive national strategy to produce green hydrogen, in addition to signing nearly 16 memorandums of understanding signed by the Suez Canal Economic Zone with global companies to localize the green fuel industry. Among these memoranda is a memorandum signed with the Australian company FFI, which aims to produce green ammonia that depends on green hydrogen with a total volume of over 2 million tons of ammonia (Wang, Liu, & Wang, 2022).

4.9 Addressing uncertainty

In order to reduce uncertainty in the renewable energy sector, the researcher sees the need to increase investment in research and development. This will help to improve renewable energy technologies and reduce their costs. In addition, governments can take steps to promote stability in the renewable energy sector (Zhao & Zhang, 2023).

5. Conclusion

The energy crisis is one of the vital topics that has attracted the attention of researchers in all fields. Many studies, including this study, have sought to investigate the causes and effects of these crises on the global economy and the Egyptian economy.

Anyway, the Egyptian economy has made progress in recent years in the energy sector. Egypt has succeeded in securing the energy sector in previous periods, especially in terms of the raw materials used to generate electricity. Egypt has also made progress in electricity production by increasing the relative weight of renewable energy. However, there are some shortcomings that decision-makers must address by developing plans to address this shortcoming, which is to enact laws related to renewable energy, especially the investment aspect. It is also necessary to introduce modern and advanced technologies in power generation and electricity.

Energy crisis is one of the most prominent challenges facing the Egyptian economy at the present time. The crisis is manifested in the shortage of energy supplies, which leads to an increase in its prices, and an increase in the burdens on the Egyptian economy. The study used neural networks to identify the causes of the energy crisis in Egypt, the most important of which are: (1) The rise in the price of the dollar against the Egyptian pound: The rise in the price of the dollar against the Egyptian pound led to an increase in the prices of imported energy, such as oil and natural gas. (2) The increase in demand for energy: The Egyptian economy is growing rapidly, leading to an increase in energy demand.(3) Exporting energy abroad: Egypt exports part of its production of natural gas abroad, which reduces the amount of energy available for domestic consumption.(4) The rise in global energy prices: Global energy prices have risen sharply in recent years, leading to an increase in energy prices in Egypt.

There are several ways to address the energy crisis in Egypt, including:(1) Diversifying energy sources: Egypt must work to diversify energy sources, so that it does not rely heavily on natural gas. This can be done by increasing investments in renewable energy sources, such as solar and wind power.(2) Energy conservation: The Egyptian government must work to conserve energy, through awareness campaigns and the implementation of energy conservation systems in government and private institutions.(3) Increased domestic energy production: The Egyptian government must work to increase domestic energy production, through increased investments in the energy sector, such as building new power plants and developing energy infrastructure.

The above-mentioned ways can be applied to address the energy crisis in Egypt, through:(1) Diversifying energy sources: The Egyptian government can work to increase investments in renewable energy sources, such as solar and wind power. The government can also work to cooperate with other countries in the field of energy, such as the Gulf Arab countries. (2) Energy conservation: The Egyptian government can work to launch awareness

campaigns to raise awareness of the importance of energy conservation. The government can also work to implement energy conservation systems in government and private institutions. (3) Increased domestic energy production: The Egyptian government can work to increase investments in the energy sector, such as building new power plants and developing energy infrastructure.

The study recommends the need to develop long-term policies for the renewable energy sector. These policies can help companies and investors make more efficient decisions about how to allocate resources. Financial support should also be provided to companies operating in the renewable energy sector. This can help reduce start-up costs and stimulate investment in this sector.

References

Alsmadi, A. A., Al-Okaily, M., Alrawashdeh, N., Al-Gasaymeh, A., Moh'd Al-hazimeh, A., & Zakari, A. (2023). A Bibliometric Analysis of Green Bonds and Sustainable Green Energy: Evidence from the Last Fifteen Years (2007–2022). *Sustainability, 15*(7), 5778. doi: https://doi.org/10.3390/su15075778

Ampe, K., Paredis, E., Asveld, L., Osseweijer, P., & Block, T. (2021). Incumbents' enabling role in niche-innovation: Power dynamics in a wastewater project. *Environmental Innovation and Societal Transitions, 39*, 73-85. doi: https://doi.org/10.1016/j.eist.2021.03.004

Bai, Y. (2025). The Impact of Green Bond Issuance on Corporate Environmental and Financial Performance: An Empirical Study of Japanese Listed Firms. *International Journal of Financial Studies, 13*(3), 141. doi: https://doi.org/10.3390/ijfs13030141

Elhelaly, D., & Algarhy, F. M. (2024). The Impact of The Green Bonds on The Financial Sustainability: Evidence From Egypt. *International Journal of Accounting and Management Sciences, 3*(2), 201-218. doi: https://doi.org/10.56830/IJAMS04202405

Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics, 142*(2), 499-516. doi: https://doi.org/10.1016/j.jfineco.2021.01.010

Flottmann, C., Köchling, G., Neukirchen, D., & Posch, P. (2025). Green debt: a systematic literature review and future research agenda. *Management Review Quarterly*. doi: https://doi.org/10.1007/s11301-025-00511-x

Fu, C., Lu, L., & Pirabi, M. (2024). Advancing green finance: a review of climate change and decarbonization. *Digital Economy and Sustainable Development, 2*(1), 1. doi: https://doi.org/10.1007/s44265-023-00026-x

Gianfrate, G., & Peri, M. (2019). The green advantage: Exploring the convenience of issuing green bonds. *Journal of Cleaner Production, 219*, 127-135. doi: https://doi.org/10.1016/j.jclepro.2019.02.022

Gonzalez-Salazar, M., Kormazos, G., & Jienwatcharamongkhol, V. (2023). Assessing the economic and environmental impacts of battery leasing and selling models for electric vehicle fleets: A study on customer and company implications. *Journal of Cleaner Production, 422*, 138356. doi: https://doi.org/10.1016/j.jclepro.2023.138356

Huo, W., Wang, X., Zulfiqar, M., Ghafoor, S., & Ullah, M. R. (2025). Spurring green bond market development through green economy and institutional quality. *Digital Economy and Sustainable Development, 3*(1), 8. doi: https://doi.org/10.1007/s44265-025-00057-6

Jones, L., & Portela, C. (2020). Evaluating the success of international sanctions: A new research agenda. *Revista CIDOB d'Afers Internacionals, 125*, 39-60. doi: https://doi.org/10.24241/rcai.2020.125.2.39/en

Khan, A., Arora, D., & Meena, M. K. (2025). Unlocking trends in green bonds: Navigating opportunities and challenges for sustainable development in E7 countries. *International Journal of Financial Management and Economics, 8*(1), 81-88. doi: https://doi.org/10.33545/26179210.2025.v8.i1.453

Kumar, P., Taneja, S., Özen, E., Khalilova, R., & Huseynov, R. (2024). Green Bonds as Catalysts for Low-Carbon Financing Mobilization: Examining their Impact on Sustainable Development. *Journal of Mehmet Akif Ersoy University Economics and Administrative Sciences Faculty, 11*(4), 1393-1417. doi: https://doi.org/10.30798/makuiibf.1466700

Negi, P., Jaiswal, A., & Rekunenko, I. (2025). Green bonds and corporate value creation: a review of financial, market, and environmental performance. *Discover Sustainability, 6*(1), 1106. doi: https://doi.org/10.1007/s43621-025-01834-1

Nguyen, L. H., & Le, H. T. (2024). Impact of Green bond on renewable energy transition. *Ho Chi Minh City Open University Journal of Science - Economics and Business Administration, 15*(3), 136-159. doi: https://doi.org/10.46223/HCMCOUJS.econ.en.15.3.3322.2025

Ning, Y., Cherian, J., Sial, M. S., Álvarez-Otero, S., Comite, U., & Zia-Ud-Din, M. (2023). Green bond as a new determinant of sustainable green financing, energy efficiency investment, and economic growth: a global perspective. *Environmental Science and Pollution Research, 30*(22), 61324-61339. doi: https://doi.org/10.1007/s11356-021-18454-7

Niyazova, M. V. (2025). Economic Sanctions, 1960-2022: Targets, Structure, Impact. *Vestnik RUDN. International Relations, 25*(2), 296-308. doi: https://doi.org/10.22363/2313-0660-2025-25-2-296-308

Okafor, A., Adusei, M., & Edo, O. C. (2024). Effects of the utilization of green bonds proceeds on green bond premium. *Journal of Cleaner Production, 469*, 143131. doi: https://doi.org/10.1016/j.jclepro.2024.143131

Ozyesil, M., & Tembelo, H. (2025). The Role of Green Bonds in Financing Sustainable Energy Projects: Trends and Prospect. *International Journal of Energy Economics and Policy, 15*(2), 370-379. doi: https://doi.org/10.32479/ijeep.16942

Saadh, M. (2022). How long-term metal and lead exposure among foundry workers affect COVID-19 infection outcomes in Jordan. *Environmental Science and Pollution Research, 29*(46), 70408-70412. doi: https://doi.org/10.1007/s11356-022-20845-3

Sanganeria, P. (2025). Green Bonds: Financing a Sustainable Future. *International Journal for Research Publication and Seminar, 16*(4), 82-96. doi: https://doi.org/10.36676/jrps.v16.i4.336

Shah, S. S., Murodova, G., & Khan, A. (2024). Achieving zero emission targets: The influence of green

bonds on clean energy investment and environmental quality. *Journal of Environmental Management*, *364*, 121485. doi: https://doi.org/10.1016/j.jenvman.2024.121485

Shang, T., Yang, L., Liu, P., Shang, K., & Zhang, Y. (2020). Financing mode of energy performance contracting projects with carbon emissions reduction potential and carbon emissions ratings. *Energy Policy*, *144*, 111632. doi: https://doi.org/10.1016/j.enpol.2020.111632

Smirnov, S., & Bulgakov, A. (2022). The Efficiency of Environmental Project Financing with Green Bonds in the Energy Sector: Evidence from EU Countries. *Journal of Corporate Finance Research*, *16*(3), 63-70. doi: https://doi.org/10.17323/j.jcfr.2073-0438.16.3.2022.63-70

Wang, D., Xiong, T., & Mohsin, M. (2024). Assessing the impact of cleaner bonds on clean energy expenditure for sustainable economic recovery: A fuzzy analytical approach. *Energy Strategy Reviews*, *55*, 101547. doi: https://doi.org/10.1016/j.esr.2024.101547

Wang, T., Liu, X., & Wang, H. (2022). Green bonds, financing constraints, and green innovation. *Journal of Cleaner Production*, *381*, 135134. doi: https://doi.org/10.1016/j.jclepro.2022.135134

Wang, W., & Zhang, Y.-J. (2022). Does China's carbon emissions trading scheme affect the market power of high-carbon enterprises? *Energy Economics*, *108*, 105906. doi: https://doi.org/10.1016/j.eneco.2022.105906

Ye, Y., & Zhang, Q. (2024). The futility of economic sanctions in a globalized and interdependent world: a data-driven game theoretical study. *Humanities and Social Sciences Communications*, *11*(1), 1034. doi: https://doi.org/10.1057/s41599-024-03518-z

Zhao, M., & Zhang, L. (2023). Foreign ownership, heterogeneous beliefs, and stock market volatility. *Finance Research Letters*, *55*, 103872. doi: https://doi.org/10.1016/j.frl.2023.103872

Zhu, Z. (2025). Exploring the Role of Green Bonds in Advancing Corporate Innovation. *Advances in Economics, Management and Political Sciences*, *156*, 158-165. doi: https://doi.org/10.54254/2754-1169/2025.20654