

Research Article

# The Electricity Crisis and the Feasibility of Nuclear Energy in Egypt

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## Abstract

The power outage crisis is increasing in Egypt, negatively affecting many other sectors such as industry, agriculture, and trade. In light of the lack of sufficient capacity to meet the growing needs of consumers, which has led to regular power shortages and power outages. While Egypt needs additional energy, the production of gas and oil needed to generate thermal energy decreased in 2014, and Egypt moved from an exporter of natural gas to a net importer. In addition to this, the volume of subsidies allocated to energy increased, the rise in global prices for oil and natural gas, and the need for huge investments to create Power generation plants, development of transportation networks, and distribution of electrical energy, which led to pressure on the general budget. A continuous and reliable supply of electricity is needed for Egypt's social and economic development. Accordingly, the government encouraged the development of new energy, invited the private sector to participate in energy generation, and a number of government reforms were made in order to enhance competition in the energy market, which required the need to study the possibility of providing it using nuclear energy. Its stations have a high load capacity, operate almost at full capacity all the time, are characterized by the stability of the electrical network and energy independence, and avoid the risks of fuel price shocks, and the costs of generating electricity from them decrease with increasing production. The importance of this research lies in highlighting the challenges facing the structure of the electricity sector in Egypt, and studying the advantages enjoyed by nuclear energy as the most important renewable energy sources in the world. Its importance also lies in comparing nuclear energy with other energy sources, and trying to benefit Egypt from obtaining this energy for use. In economic development projects, rationalizing tariffs and supporting their access to the poor. *This research is divided into: The first topic:* The electricity generation crisis in Egypt and a development vision for the contribution of nuclear energy to its solution, *The second topic:* trends in development planning for establishing nuclear plants in Egypt. The electricity generation crisis in Egypt and a development vision for the contribution of nuclear energy to its solution.

## Keywords

Oil, Fuel Prices, Natural Gas, Electricity, Carbon Emissions, Fossil Fuel Subsidies, Nuclear Energy, Egypt

## 1. Introduction

The electricity crisis in Egypt is an escalating crisis that requires confronting it and working to develop solutions to it. To raise its negative impact on the various sectors of the

economy, the crisis is mainly due to the shortage of fuel needed to generate electricity from the used diesel, natural gas, and diesel, in addition to the low efficiency of the current

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stations. This crisis contributes to the exacerbation of the budget deficit due to the direct support provided to this sector, which leads to This leads to a decrease in the stability sought by the political authority, which negatively affects the national economy as a whole, and the continued deterioration of the cash reserves used to import gas and diesel, and then the deterioration of the value of the local currency.

## 2. The First Axis: Analysis of Current Trends in Energy Production and Consumption in Egypt

### 2.1. First: Oil Consumption and Production in Egypt

Energy consumption levels rose in Egypt with the increased growth rate and expansion of the economy, and dependence on oil and the volatility of its market forced us to seek more stable ways to produce electricity to support economic activity and to meet the increasing demand for electricity. Countries began to increase their production capacity, in order to ensure economic growth in an environmentally and economically sustainable manner. We notice in the following figure the increase in oil consumption compared to production in Egypt during the period from 2012 to 2017.

The severe shortage and the burden imposed by the impact of oil create an economic disadvantage; The consumption of petroleum products is increasing at an alarming rate, as the supply cannot meet the demand, and therefore the energy sector is facing a major electricity crisis, which requires

shifting the use of energy from fossil fuels, and shifting the incentives allocated to fossil fuels and financial subsidies for petroleum to the development of new energy. To make technology accessible to low-income people.

### 2.2. Second: Fuel Prices in Egypt

The sharp rise in global oil prices has led to expectations of higher oil prices in the future. Although Egypt is the fifth largest oil producer in the world outside of OPEC, resources are decreasing rapidly. Fluctuations in oil prices have a significant impact on economic activity, and increasing prices lead to a rise in oil prices. Production costs and rising inflation rates.

The fluctuation of oil prices in the international market also puts negative pressure on any oil-importing economy. Due to the high cost of imports, increases in oil prices lead to a high cost of production, and as a result the economy endures a high level of prices, low economic growth and unemployment, and the decline in domestic prices for oil has led to a massive growth in demand for it, which has harmed oil-exporting countries and led to wasted energy. As for gas, the demand exceeds the capacity of electricity generation stations from gas fuel in Egypt, which means that Egypt faces a supply problem. Part of its natural gas reserves are exported at low prices. [1]

The expectation that oil prices will continue to rise in the future has stimulated technological changes and the shift to alternative fuels. The oil crises were a major impetus to increase research and development efforts to find alternative local energy sources. As it will make the economy less dependent on foreign energy sources, and thus more resistant to external shocks.

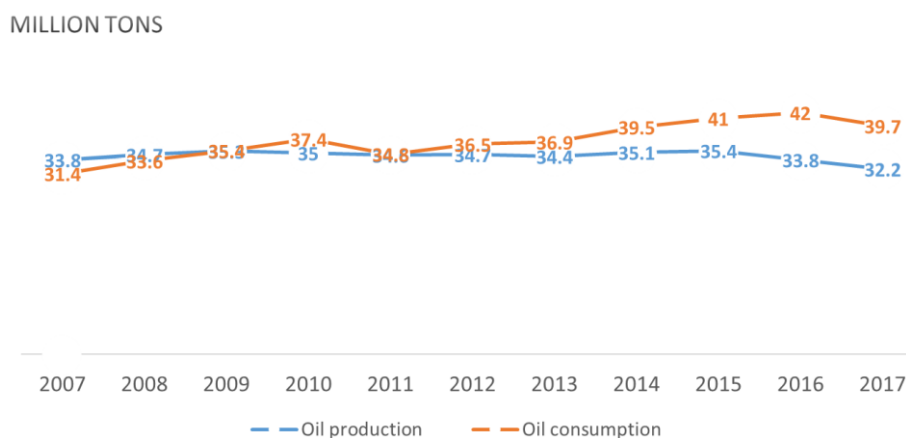
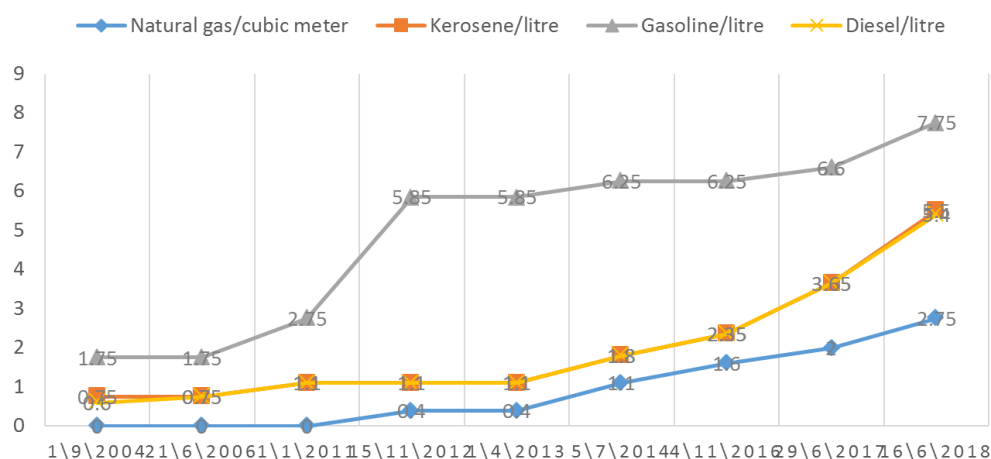


Figure 1. Oil production and consumption in Egypt.

Source: BP review of world energy 2017.  
<https://www.bp.com/content/dam/bp/en/corporate/pdf/energyeconomics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf> page 16, 17

**PRICE(EGYPTION POUND)**

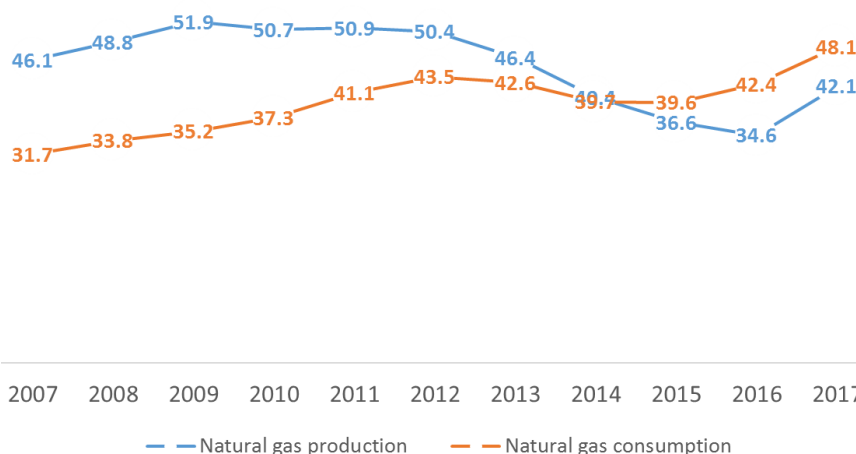
Source: Prepared by the researcher according to data from the following website <https://www.thefuelprice.com/Feg?lang=en>

**Figure 2.** Fuel prices in Egypt.

The figure shows the government's tendency to raise fuel prices in Egypt. Due to price distortions resulting from selling petroleum products at less than their cost, which limits the realization of added value and hinders development opportunities. Accordingly, the price of fossil fuels has a significant impact on the share of alternative and renewable energy in the energy mix. The higher the price of fuel used to generate energy, the more economically feasible it becomes to deploy alternative and renewable energy. [2]

### 2.3. Third: Production and Consumption of Natural Gas in Egypt

The overall demand for natural gas in Egypt accelerated; Due to the shift of thermal power plants (which represent 65% of Egypt's total consumption) from oil to gas, in addition to the decline in gas production to 49 billion cubic meters in 2014, and as shown in the following figure, production is less than consumption at a rate of -2.6%.

**MILLION OIL EQUIVALENT TONS**

**Figure 3.** Natural gas: production in one million tons of oil equivalent.

Source: BP review of world energy 2017. <https://www.bp.com/content/dam/bp/en/corporate/pdf/energyeconomics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf> page 30, 31.

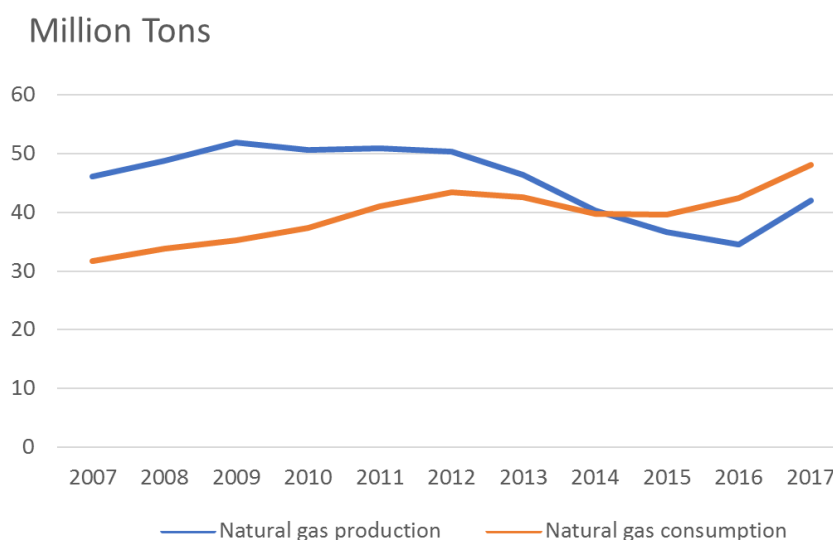
Egypt transformed from an energy exporter (natural gas) to a net importer (oil and petroleum products). Due to the increase in domestic demand and the decrease in exploration and production activity as a result of indebtedness to foreign partners after the 2011 revolution, Egypt ranked twentieth among the 20 largest countries in the world for burning gas during the period from 2007 to 2017.

From an environmental perspective, the combustion of gas is linked to greenhouse gas emissions, and carbon emissions have increased from the combustion of natural gas in Egypt, which contributes to global warming. From a social perspective; Gas flaring poses a threat to human health and ecosystems in nearby locations, and from an economic perspective;

Burning gas is a waste of non-renewable natural resources, and therefore the Egyptian government should change its current approach to energy support and pricing in order to stimulate the adoption of economically efficient measures and rationalize its consumption. [3]

#### *Fourth: Electricity production and consumption policies in Egypt*

Electrical energy is considered one of the basic pillars of social, scientific and industrial development, as well as the main engine of progress. Energy consumption has developed due to the increasing population growth rate, in addition to the growth of the industrial sector, which has caused a change in the economic structure of the electricity sector.



Source: Prepared by the researcher according to data from the following website. <https://www.indexmundi.com/g/g.aspx?v=81&c=eg&l=en>

**Figure 4.** Electricity consumption and production in Egypt.

It is noted from the figure that the pace of growth of electricity consumption in Egypt is accelerating at the same rate as production increases. Economic growth affected consumption patterns and led to a gap between demand and supply, and the reason behind the continuing shortage in electricity supplies was weak planning, lack of coordination, and ineffective institutions. This situation necessitated the need to find a balance between consumption growth and production for reliable electricity supply; Electricity consumption in Egypt is increasing at a faster rate than production. Which led to the lack of sufficient and safe supplies of energy at commensurate prices, in addition to environmental damage resulting from excessive consumption.

#### *Fifth: Electrical energy indicators and demand expectations in Egypt*

##### *1. Electric power generation in Egypt*

The demand for electricity has increased significantly in Egypt due to social and economic development, as shown in the following figure: In 2016, the generated energy was 186,320 gigawatts per hour, and the average rate of development of generated energy reached 4.3% annually during

the period 2011/2012 to 2015/2016.

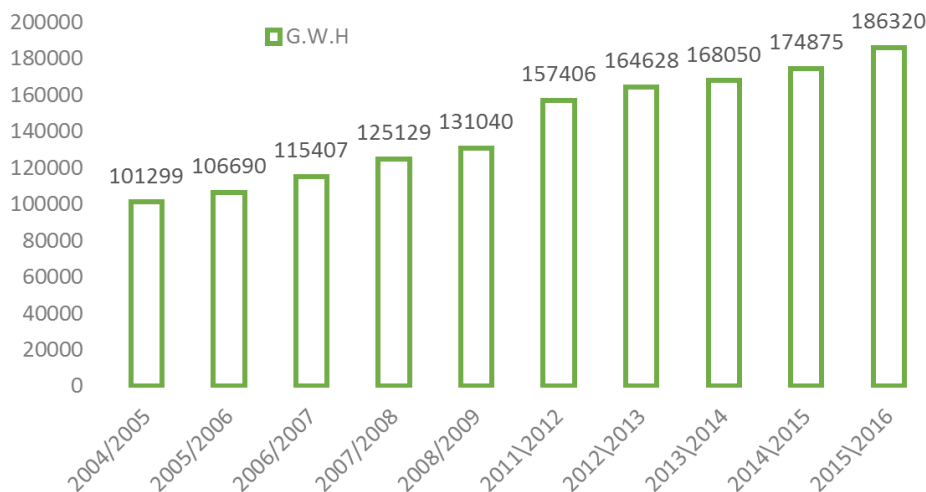
Egypt is facing a crisis in the production, generation and distribution of electricity. Which negatively affects the economy's ability to grow. With the increasing need for electricity, the increasing shortage of oil and gas reserves, the increase in demand for energy, the fluctuation of its prices, and the link between energy and development; Resorting to the option of nuclear energy as a source of electricity generation has become a strategic option to diversify energy sources, and relying on oil and gas alone to generate electricity in light of the steady increase in electricity is considered a strategic flaw in the state's methodology followed, while nuclear energy is the alternative available at the global level to fossil fuels. To supply essential electrical loads; It can generate large amounts of electricity at a cheap cost. [4]

The energy crisis in Egypt is the result of a number of overlapping factors, including high demand, shortages in natural gas supplies, aging infrastructure, political instability, insufficient generation and transmission capabilities, and a decline in oil reserves. Accordingly, Egypt became a net importer of oil. The sharp increase in domestic oil consump-

tion has negatively affected the amount available for exports, transforming Egypt from a net exporter to a net importer.

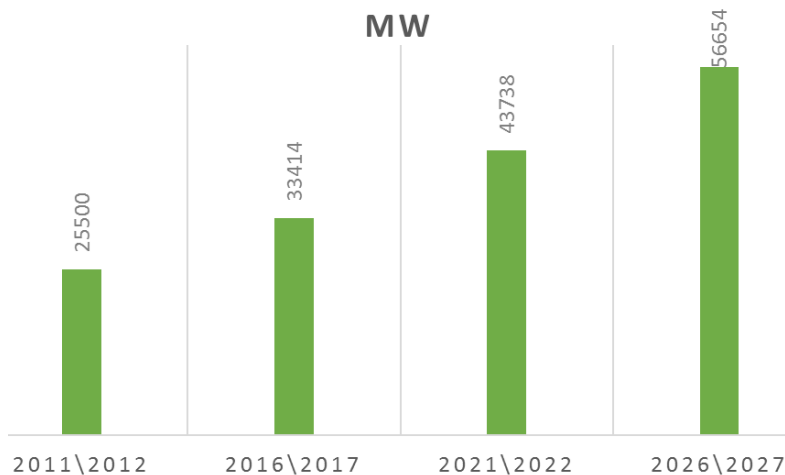
## 2. Peak electricity load in Egypt

The increase in energy demand led to an increase in the peak electricity load on the network, as shown in the following figure, where the peak demand in 2012 reached about 25,500 megawatts, and it is expected to reach 56,654 megawatts by 2027. Accordingly, the government plans to increase the rate of renewable energy sources (Including nuclear energy) in the electricity mix to 20% by 2020.



**Figure 5.** Development of generated electrical energy (gigawatt hours).

Source: Manfred Hafner, Simone Tagliapietra and El Habib El Andaloussi (16/October 2012), Outlook for Electricity and Renewable Energy in Southern and Eastern Mediterranean Countries, i MEDPRO Technical Report pag 13.



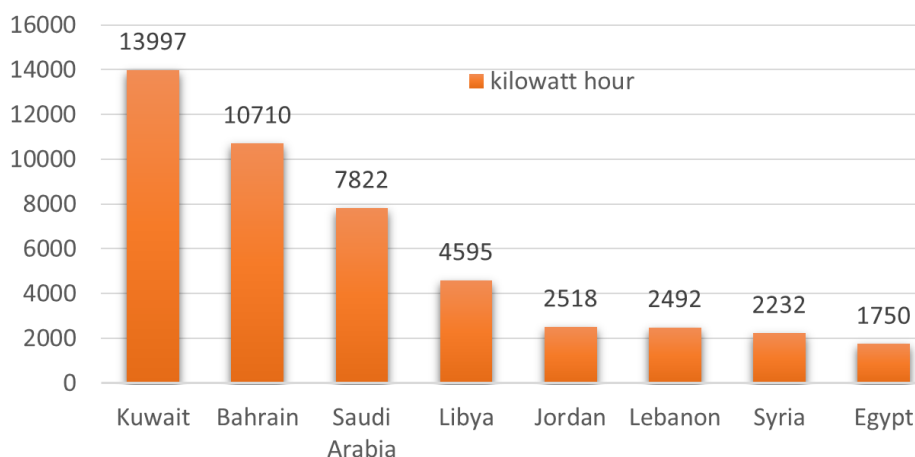
Source: Mostafa Ibrahim Khamis. Fouad Mohammed Mansour. Shaher Anis Mahmoud Mahmoud, Electricity sector in Egypt. Page 16.

**Figure 6.** Evolution of peak load until 2027.

## 2.4. Per Capita Consumption of Electrical Energy in the Arab World

The amount of electricity an individual receives is one of the indicators of a country's economic development, and Egypt is the country in which the individual enjoys the least economic well-being. This is evident from the large variation

in the share of electrical energy consumption in Arab countries. It reaches a maximum of 13,997 kilowatts annually in the State of Kuwait, and a minimum of 1,750 kilowatt hours in the State of Egypt. The ongoing political and social unrest in Egypt has also delayed the government's plans to expand electrical power generation capacity by 30 gigawatts for the year 2020 and activate the nuclear program. [5]



**Figure 7.** Per capita consumption of electrical energy in the Arab world.

Source: Asmaa Nour El-Din, Mahmoud Kamal, Suzan Qutb, February 2012, The reality and future of electricity in Egypt and the world, Information and Decision Support Center, Council of Ministers, p. 10, sixth year, issue 62).

In summary of the above, electricity is one of the driving forces for the economic development of all countries, and both developed and developing countries face a continuous challenge in generating electricity and meeting the increasing demand, which puts enormous pressure on the energy infrastructure, and the electricity generation crisis in Egypt requires the need to study the possibility Using renewable energy to solve this problem. Renewable energy also works to reduce pollution resulting from the use of traditional methods of generating electricity, effectively and continuously implement physical control and accounting practices, and prevent misuse of facilities. The goals set by the government in the energy sector are to increase generation capacity at the lowest cost, and to use local resources while preserving the environment. The effects of energy crises and electricity shortages are summarized as follows:

1. Weak, suboptimal energy infrastructure, financial irregularities, and lack of revenues. Government-owned power generation units showed a lack of efficiency due to poor maintenance and operation.
2. The supply is insufficient and the electricity mix is uneconomical.
3. The escalation of oil prices, the rapid depletion of domestic gas reserves, the insufficient infrastructure for natural gas, and the continued heavy reliance on oil and natural gas fuel may increase the threat to the country and its economic security.
4. Institutional weakness and the resulting defect in planning and development policies led to the impediment of formulating a coherent and comprehensive energy policy, which ultimately contributed to the failure of the sector to meet the energy needs of the national economy.
5. Tariff policy is one of the important issues in the energy sectors. The failure of governments to realign prices with basic costs and to establish price supports has greatly undermined the financial capacity of the electricity sector.

6. The market structure dominated by the state entity no longer serves the public interest. International experience indicates how the market structure, which is largely dominated by state-owned interests, can support a new, effective economic formation and other investment decisions.
7. The lack of diversity in electricity supply sources poses a threat to the stability of generation and potential price fluctuations, which requires restructuring the energy sector.
8. Decrease in industrial production and loss of credibility in the global market due to unstable networks and outdated infrastructure.
9. The impact on the economy, the decline in gross domestic product, foreign investment in the country, and the potential financial crisis of increases in electricity prices.
10. Increased carbon dioxide emissions; Due to the use of electrical thermal generation that is not suitable for the primary load. [6]

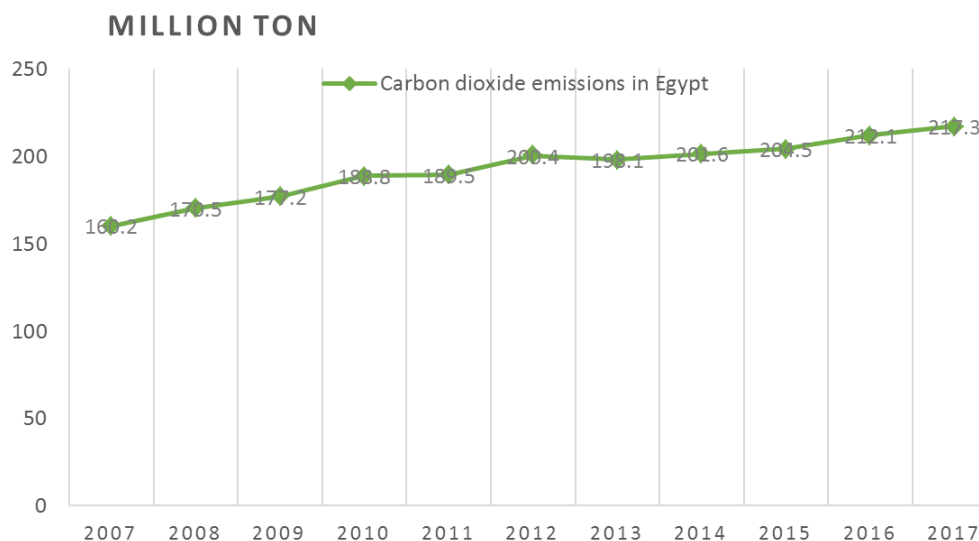
### 3. The Second Axis: The Environmental and Economic Problems of Producing Electricity from Fossil Fuels in Egypt

*First: The environmental problems of producing electricity from traditional sources in Egypt*

*Carbon dioxide emissions in Egypt*

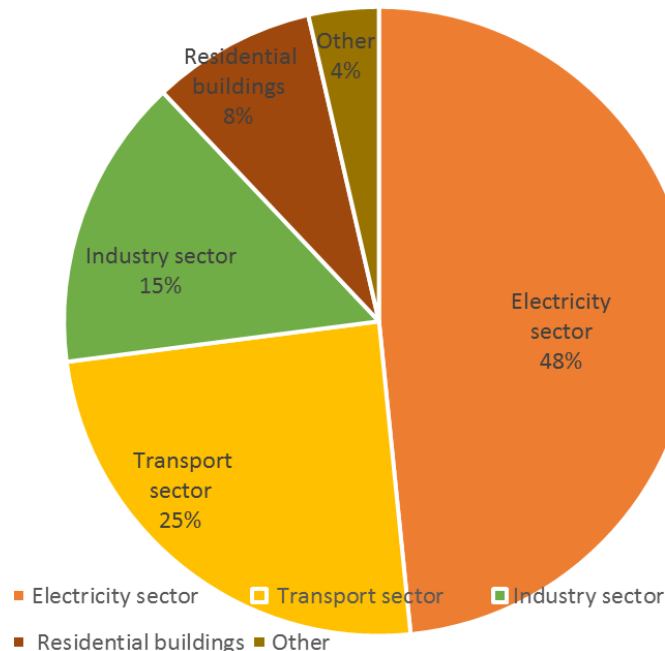
Climate change poses potential threats to economic growth and the potential for increased poverty in countries Developing; Supporting accelerated economic growth and high standards of living around the world was based on the increasing use of natural resources, especially energy from fossil fuels, and thus was a key element in climate change. Current efforts to reduce greenhouse gas emissions revolve around removing carbon from the energy sector, and then promote the use of renewable energies. It is clear from the

figure that carbon dioxide emissions in Egypt have increased i.e. increasing at a rate of 3.4%. [7]  
from 160.2 million tons in 2007 to 217.3 million tons in 2017,



**Figure 8.** Carbon emissions in Egypt.

Source: BP review of world energy 2017.  
<https://www.bp.com/content/dam/bp/en/corporate/pdf/energyeconomics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf> page 49.



**Figure 9.** Sources of carbon dioxide emissions in Egypt (2017).

Source: ElShennawy, T., & Abdallah, L. (2017). Evaluation of CO<sub>2</sub> emissions from electricity generation in Egypt: Present Status and Projections to 2030.

It is worth noting that economic growth is the main factor that increases carbon dioxide emissions, mainly due to the

existence of a positive relationship between economic development and demand for electricity, as the steady rise in



demand for electricity leads to an increase in carbon emissions. In light of this, the government must develop a support policy, a legislative protection system, and a standard for reducing carbon emissions. A carbon price is an essential element in any policy mix to stimulate the transition towards a low-carbon economy. Moreover, a carbon price carries the added advantage of raising public revenues, which can be used to promote development and increase the economic viability of climate policy.

Fossil fuels are not only a source of greenhouse gases, but they are also a source of various types of pollutants, so increasing energy efficiency and switching from carbon to renewable energy sources are the main tools. A policy for implementing climate change policy by including climate risks in strategies Development, the energy sector should be considered in a better mix of electricity sources that reduce environmental degradation without harming growth, and to deal with climate change, fossil fuel subsidies are removed. As the following figure shows, the electricity sector represents the largest source of carbon emissions, emitting 48% of carbon.

The researcher believes that development and growth are one of the important tools that require increasing the depletion of electrical energy, as Egypt is going through a phase of tremendous economic and urban growth in light of the construction of new cities, the opening of economic projects, and the construction of roads. Which requires a program to restructure the electricity sector and provide an infrastructure that can bear more pressure on local consumption indicators. This calls for the government to build national policies in order to develop the energy generation system based on renewable natural sources that limit carbon dioxide emissions, by encouraging investment in it. Supporting reliance on nuclear energy technology and integrating it into the current energy system, to build more efficient systems, and supporting the localization of this technology in Egypt.

## 4. Conclusion

We note that the rise in traditional energy prices will encourage investment in clean energy, and developed countries must bear the primary responsibility for reducing emissions and provide financial support to developing countries. Energy justice is a global systemic goal to achieve efficiency, based on designing a consistent share of energy sources, and international commitment from developed countries towards developing countries is necessary to enhance their resilience and economic preparedness, and adapt to climate-related events.

In light of these indicators, nuclear energy is one of the most possible measures to confront the challenges of increasing energy demand, and the best solution to secure energy use for future generations, reduce concerns about environmental impact and climate change, and provides a promising alternative to traditional energy sources for countries that face restrictions in meeting their electricity needs in the

future. The future, in addition to the imperative of providing energy at acceptable prices that ensures safe transportation and distribution to local consumers.

Second: The economic problems of producing electricity from traditional sources in Egypt

### 1) Electricity support policies in Egypt

Energy subsidies are used to support economic development by enabling access to affordable energy services and expanding access to them for the poor, which indicates that subsidies help reduce initial costs for poor consumers. Subsidizing electricity prices from clean energy has played a major role in reducing power plant emissions. Hence, reforming electricity subsidies and labor market policy require that renewable energy be introduced into the energy mix in Egypt, and continued reliance on support programs to support renewable resources and other zero emissions. Governments usually provide financial support by introducing support plans, grants, or tariff systems. [8]

Eliminating electricity subsidies and adjusting its price has an important role in reducing pollution emissions. As it will lead to a decrease in demand for electricity, and to avoid harmful climate changes, the carbon intensity of economic activity must be reduced. Accordingly, pumping more money to support fossil fuels may lead to a deficit in the government's budget, which means that it places a large financial burden on the economy. The country's budget deficit forced the government to take action to gradually reduce the level of subsidies, which caused fuel prices and electricity tariffs to rise. Fossil fuel subsidies contribute to increasing the concentration of carbon dioxide emissions in the atmosphere, discouraging investments in low-carbon technologies, and harming the achievement of climate goals.

Subsidies also distort the relative prices of energy options, leading to overexploitation of fossil fuels and exacerbating the associated environmental costs. Consumer subsidies for fossil fuels in Egypt are among the largest in the world. Therefore, reforming fossil fuel subsidies is important for the low-carbon transition and replacing fossil fuels with alternative energy. Energy and carbon taxes have the potential to reduce emissions in the long term.

### 2) The current situation of electricity subsidies in Egypt

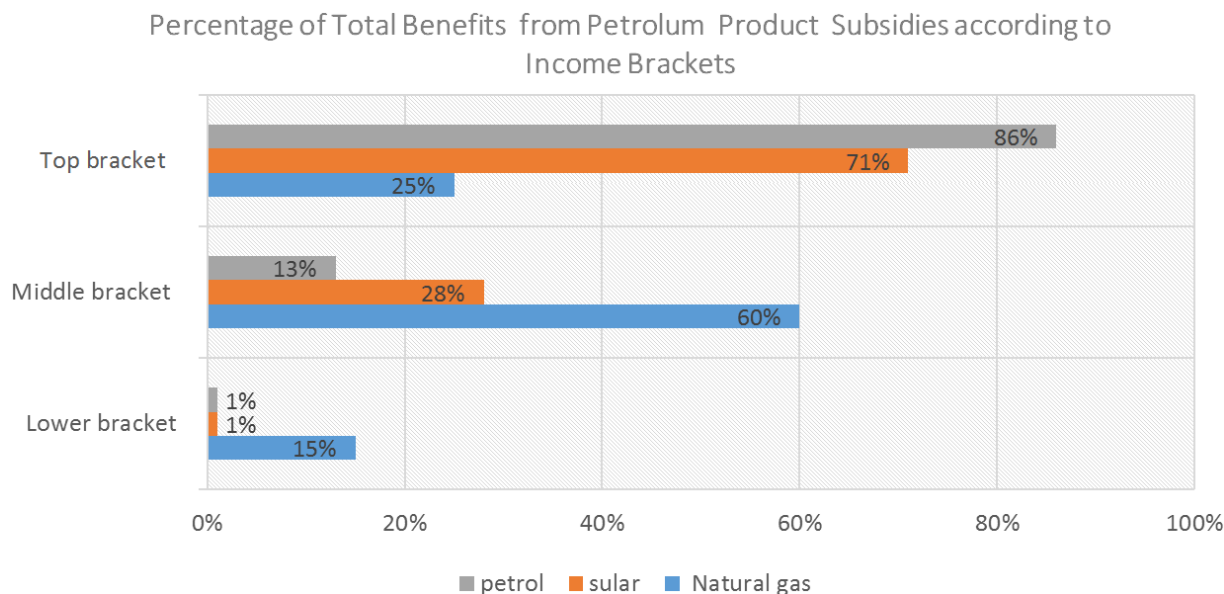
The decrease in fuel subsidies (diesel and gasoline) leads to increased economic growth by redirecting subsidies towards more productive investments such as infrastructure and other public goods (such as health and education). Under those circumstances, the energy sector in Egypt witnessed fluctuations, especially in the petroleum sector, which This affected the electricity sector, and the occurrence of outages that peaked in 2014, which prompted the state to amend the system of subsidizing petroleum products by gradually lifting subsidies starting in 2014, as energy subsidies in Egypt contributed to an increase in demand for energy, as a result of the policies of the Ministries of Petroleum and Electricity. Which created traditional energy sources with high subsidies directed primarily to the poorest fifth of the population, espe-



cially gasoline and diesel, but these policies benefited the upper middle classes and the highest income segment. [9]

In addition, 86% of gasoline subsidies went to the richest 10% in Egypt, and 60% of natural gas subsidies went to the middle class until 2013/2014, and fossil fuel subsidies con-

sumed more than about 14.5% of the GDP until 2014. From the National Health Services budget, this is in addition to causing a large budget deficit as a result of the state's reliance on imports to fill the gap between demand and supply of energy, as shown in the following figure:



**Figure 10.** Benefits of fossil fuel subsidies by income.

Source: Clements, B., Coady, D., Fabrizio, S., Gupta, S., Alleyne, T., & Sdravovich, C. (2013). Reforming Energy Subsidies: Lessons from Experience. In Energy Subsidy Reform: Lessons and Implications. INTERNATIONAL MONETARY FUND.

One of the indicators of this in Egypt is that the broad government spending on subsidizing fossil fuels is higher than the combined spending on defense, education, health, and social security. It is worth noting that these subsidies are not beneficial to the economy, because imports put pressure on the budget, and subsidies can be better used to spend on education, health, and development. Infrastructure. The gradual removal of fossil fuel and electricity subsidies, coupled with the right reallocation plans will benefit the economy, resulting in an increase in real GDP of 0.4% in 2020.

In addition, pumping more money to support fossil fuels may lead to a deficit in the government's budget, and in light of these indicators, the budget deficit forced measures to gradually reduce the level of subsidies, which led to raising fuel prices and electricity tariffs in 2018. Accordingly, Reforming fossil fuel subsidies is good for the economy and a solution to the problem of climate change, but it has negative short-term effects on low-income families and small and medium-sized businesses. [10]

Moreover, eliminating subsidies could pave the way for many other sustainable development policies, such as those that increase energy efficiency and the share of clean energies; Because providing support to fossil fuel industries placed a heavy burden on the government's public finances, and dis-

couraged investments in other sectors such as renewable energy, and reforming fossil fuel support in all countries will lead to an increase in energy productivity, which in turn leads to a decrease in demand for fossil energy, and investment in Renewable energy generation compared to business as usual. It will also encourage switching to cheaper sources of energy, which will mitigate the impact of price increases, in addition to saving capital costs in the energy sector.

### 3) The effects of energy subsidies in Egypt

Energy subsidies often contribute to large fiscal deficits, as they divert resources away from spending categories that are most conducive to growth and poverty reduction, and often hinder economic diversification and reduce incentives to adopt innovative, energy-efficient technologies. Energy subsidies in Egypt have the following effects:

- (1) The difference between the international price and energy subsidies negatively affects Egyptian public debt; Excessively high levels of demand in the markets lead to an increase in debt.
- (2) The low price encourages overconsumption if consumers are paying the real prices for oil and gas. (3) Increasing domestic consumption, which is constantly growing compared to domestic production, thus reducing export potential and depriving Egypt of poten-

tial export revenues.

- (3) Egypt will actually become a net importer of oil, with clear negative effects on its balance of trade.
- (4) Rationalizing natural gas subsidies in the power generation sector is an effective way to ensure long-term economic development and address environmental issues, as the government is reducing subsidies on natural gas used by the power generation sector as a way to address budget concerns and over-consumption.

The researcher indicates that subsidizing electrical energy in Egypt has negative effects, represented in reducing alternative economic opportunities for the optimal use of renewable sources (such as nuclear energy), as the subsidized prices of electricity represent an attractive factor for traditional fuels, and the reason is as follows:

A - Electricity subsidies do not reach those who deserve them, as those who use the most electricity and not the poorest benefit from the subsidy.

B- Reducing the price paid to producers will reduce the return on investment in the electricity sector. Which leads to a lack of incentive for investors to modernize and develop.

T - It represents a financial burden on the budget of electricity companies if they bear it, as electricity subsidies affect the general budget deficit.

D- Electricity subsidies have a negative impact on the balance of payments. Due to the resulting increase in demand for electricity, which may lead to a decrease in the amount of energy available for export, or an increase in the import bill; Which negatively affects the ability to provide electrical energy as a result of relying on imports to cover local energy needs. [11]

The researcher indicates that there are strong reasons for reducing energy subsidies. He is:

- a) It drains capital from the government budget.
- b) hinders regional integration; Because countries fear subsidized energy products leaking to other countries if their energy markets are integrated.
- c) Disproportionally benefits the rich; Because they consume the most energy.
- d) Eradicates energy poverty; Because money is not being generated to invest in expanding infrastructure to serve new consumers.

One of the implications of this is that improving the performance of the electric power sector in Egypt requires consideration of the availability of energy policies. Including supporting investments and setting construction standards to promote industrial development based on clean energy infrastructure; To support sustainable initiatives and improve the country's competitiveness, and to give priority to continuing efforts to invest in developing alternative energies as an essential tool for sustainability, and its growing participation in the energy mix.

The researcher believes that Egypt uses financial subsidies to support the energy sector, as this tool can contribute to building an integrated system. Through electrical power generation projects using unconventional tools; To modify the course of economic depletion and environmental pollution resulting from the generation of electric power by traditional methods, and that subsidies are one of the powerful policy tools in the hands of the government that can be used to correct economic and environmental impacts, the primary goal of electricity subsidy must be to provide relief to low-income electricity consumers to maintain social justice. And providing local support for energy prices with the aim of redistributing national resource wealth. The researcher attributes this to the necessity of achieving social justice in providing renewable energy to low-income people through clean energy, which can be generated for each housing unit independently, and this in turn supports economic reform plans related to at a discount Support and redistribution of resources and wealth to those who deserve it. [12]

*The third axis: A development vision for nuclear energy in Egypt*

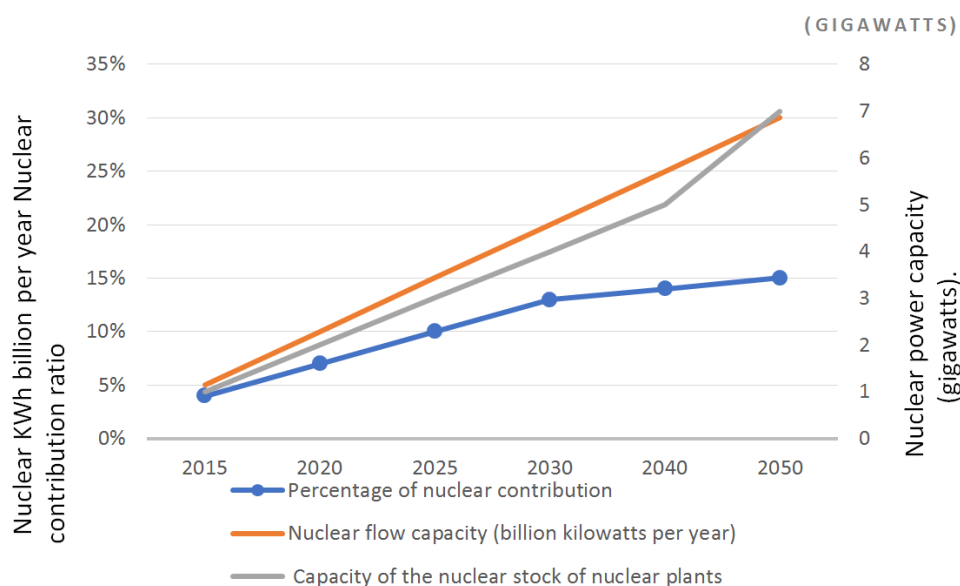
The Egyptian government aimed to establish a new energy supply infrastructure that supports the principles of sustainable development and is capable of meeting all the requirements of national needs, maximizing the efficient use of its resources, and achieving economic growth, social justice, and environmental protection.

*First: The nuclear capacity required for Egypt in the period (2010-2050)*

Egypt's potential in the field of nuclear energy is possible and necessary from an economic standpoint. However, this feasibility is not universal, but is conditional on multiple critical factors that act as restrictive constraints on nuclear feasibility with regard to planning, implementation and life-long operation. This requires studying the following: (1) the feasibility of using nuclear technology in order to sustain the needs of the Egyptian economy in the future, (2) the critical factors behind choosing the appropriate technology to meet energy demand, reduce technological risks, and provide cost-effective nuclear solutions. (3) A comprehensive assessment of the required density of nuclear reactor technology for energy security in Egypt.

Here, three interconnected requirements for nuclear supply must be stated:

- (1) Capacity for nuclear flow (one billion kilowatt-hours per year).
- (2) Nuclear contribution ratio (defined as the ratio of nuclear supply according to total electricity demand expectations).
- (3) The capacity of the nuclear stockpile of nuclear stations (LWR) (GWe of nuclear energy).



Source: Selim, T. H. (2009). On the economic feasibility of nuclear power generation in Egypt. Egyptian Center for Economic Studies, pp10.

**Figure 11.** Egypt's nuclear capacity requirements (2010-2050).

As shown in the figure, Egypt's nuclear energy requirements for its contribution to the total electricity supply reach a target share of 4% in 2015, 12% in 2030, and 15% in 2050. The long-term goal is to achieve 30 billion kilowatt hours in the year of generating electricity using nuclear energy with a capacity to install station reserves of 7 gigawatts, distributed through 6 nuclear power stations, and this is determined in the following timetable:

- i. The nuclear contribution share is 4% by 2015-2017 (the first nuclear plant).
- ii. The nuclear contribution share is 7% by 2020 (the second nuclear station).
- iii. The nuclear contribution share is 10% by 2025 (the third nuclear station).
- iv. The share of nuclear contribution is 12% by 2030 (the fourth nuclear station).
- v. The share of nuclear contribution is 13% by 2040 (the fifth nuclear station).
- vi. The share of nuclear contribution (long-term goal) is 15% by 2050 (the sixth nuclear station).

The researcher believes that nuclear technology is considered feasible to generate a gradual share of the expected electricity in Egypt, and thus there will be a need for infrastructure investments in regional transmission networks and local power lines. The researcher notes the necessity of an effective partnership between governments, civil society, and regional institutions to provide the necessary funding for sustainable development projects, and points out the importance of searching for more modern financing mechanisms in cooperation with international partners. Then move towards capacity building and advisory studies for technical support and promotion of this technology. [13]

*Second: The feasibility of nuclear power plants and the inevitability of their use in Egypt*

We note that the state can obtain significant macroeconomic benefits through effective hedging against fluctuations in fossil fuel price risks, thus avoiding costly economic losses, and its entry into the nuclear program enables it to obtain diverse energy systems that are essentially more powerful to avoid shocks.

#### *1) Reasons for resorting to operating nuclear plants in Egypt*

There appeared to be an urgent need for a new attempt to use nuclear plants to produce electricity in Egypt based on the following reasons:

1. Egypt is currently suffering from a weak financing capacity to provide its energy needs, especially oil, in light of the rise in oil prices.
2. Egypt has become an oil importing country.
3. Development's energy needs cannot be met by relying solely on traditional energies.
4. Egypt does not possess any sources of coal, and in addition to that, the external sources of its availability add unforeseen burdens in securing those sources and the means of transporting it from them, as they are all from distant sources, in addition to its environmental effects, and the need to prepare an integrated infrastructure, which is not Currently available when using coal power plants.
5. Earning export revenues from the sale of fossil fuels abroad is an attractive option, especially for developing countries.
6. Concentrations of carbon dioxide have risen in the atmosphere, which has increased global warming and climate change. In addition, developing countries are highly vulnerable to climate change because they face greater risks to infrastructure, humans, and natural systems, but their economies have fewer resources - socially, technologically, and financially - to adapt to These risks.

## 2) Reasons for the need for nuclear research in Egypt

The social and economic importance of nuclear science and technology centers lies in the development of the high-tech industry, which requires support for nuclear research, for the following reasons:

1. Encouraging the exchange of technology and innovations at the national, regional and international levels.
2. Solving development problems in the fields of health care, agriculture and industry.
3. Implementing innovative experiments, raising the general level of scientific knowledge, and establishing centers to train future nuclear students and scientists.
4. Improving the country's position at the regional and international levels, and the development of nuclear energy contributes to the growth of scientific research and national intellectual capabilities.
5. Developing the skills and specializations necessary for the industrial use of nuclear energy.
6. Strengthening the national economy through the use of advanced nuclear technology.

## 3) Factors of nuclear energy's contribution to sustainable development in Egypt

The pillars of an integrated offer for establishing a nuclear plant are access to a full range of services throughout the life cycle of the plant; To provide a customized project suitable for the local environment through:

1. Nuclear infrastructure: Preparing the client's country to host the nuclear facility in accordance with the national regulatory program based on experience in cooperation with foreign clients.
2. Popular acceptance: increasing public awareness of the benefits provided by nuclear electricity, and support in social research; To measure public opinion's acceptance of the idea of developing the nuclear industry.

3. Human resources development: Highly qualified personnel ensure the safe and efficient operation of commercial and research reactors, and then focus on training the local workforce.

4. Maximizing local participation and localization of the industry: enabling local suppliers to contribute to the national program, and giving an impetus to the local economy; It is possible for local companies to participate in implementing civil works, installation activities, and supplying equipment.

5. Fuel supply: Providing a full range of fuel cycle management solutions in nuclear power plants, starting from fuel manufacturing to processing spent nuclear fuel; To ensure the continued flow of energy to the national grid.

6. Ensuring radiation safety and preserving the environment: Providing environmentally friendly solutions for treating spent nuclear fuel and radioactive waste, decommissioning nuclear facilities, and operating and maintaining them by managing safe operation and generating affordable energy. [14]

## Third: The cost of establishing a nuclear station in Egypt

Nuclear fuel sources contain more energy than can be obtained from other types of fuel. Therefore, nuclear energy has imposed itself in the field of electricity generation, and Egypt is trying to adopt this method at the present time, due to the inevitable decline in the cost of producing nuclear energy in the future from the cost of producing it by traditional means. In light of this, the industrial renaissance of developing countries will not be achieved in the long term except on the basis of providing Nuclear-produced electrical energy, in addition to the necessity of acquiring scientific expertise in this field; Nuclear power plants and the reactors attached to them are considered exemplary centers for the development of nuclear science and technology in Egypt.

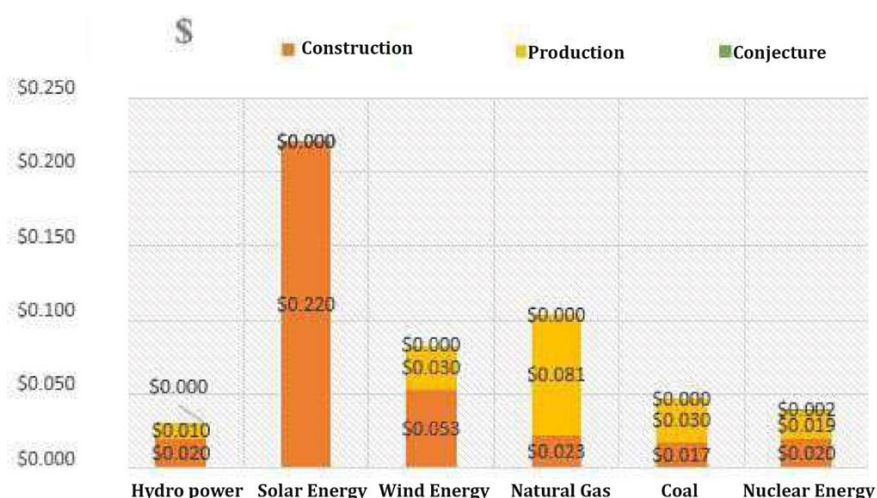


Figure 12. Costs of energy sources in Egypt.

Source: El-Osery, I. A. (2015). The Egyptian Nuclear Power Project and IAEA Technical Assistance in Supporting the Project and its Nuclear Safeguards (No. IAEA-CN-220).

As shown in the previous figure, nuclear energy is less expensive compared to other sources, and for a nuclear station the cost of fuel is usually low compared to fossil fuel stations. Estimates vary, but according to the Nuclear Energy Institute in the United States, the cost of fuel represents about 28% of the cost of electricity of a nuclear power plant compared to 78% for a coal-fired power plant, and 89% for a gas-fired power plant. This means that any fluctuation in nuclear fuel prices will have a less impact on the cost of electricity than it does in a gas-fired power plant. Fossil fuel power plants require large quantities of fuel, and supplies of some fossil sources may be vulnerable to political influence and economic turmoil, such as oil crises, especially in the long term.

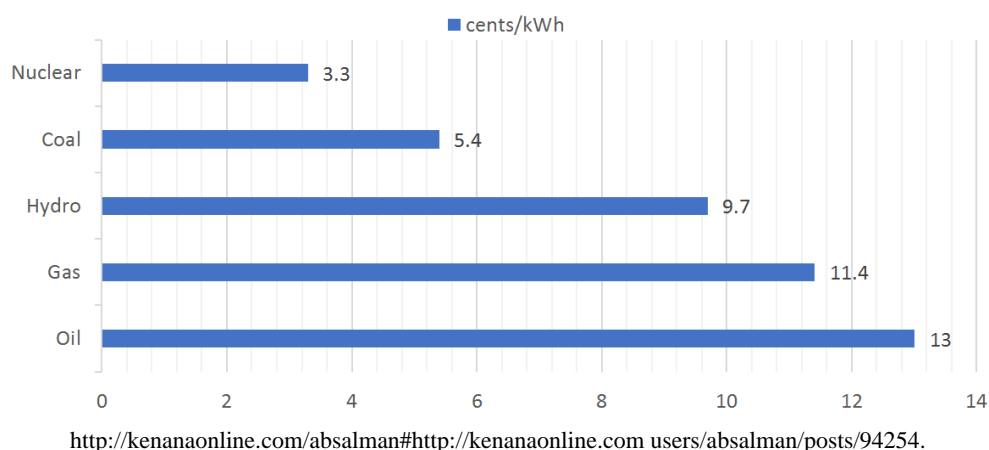
According to this vision, nuclear energy is seen as a basic technology for future low-carbon systems, and excess electricity production is exported to the external market. We note that the high investment cost and long completion period are among the most prominent disadvantages of nuclear energy, but on the other hand, its production efficiency is greater than solar energy, and in general solar energy is better than nuclear

energy. But the lack of sunshine in all regions and at all times makes it economically unviable in many areas. [15]

Also, most countries that consider nuclear energy as the main source of electricity production do not have a large area or fossil fuel wealth, as in this case relying on nuclear energy is less expensive than relying on fossil fuels, and it does not need large areas like renewable energies. This was confirmed by the fact that some countries, despite being exposed to nuclear disasters, still depend on nuclear energy as a major source of electricity production.

*Fourth: Comparison between kilowatts of electricity produced from different energy sources*

It should be noted that the high costs of constructing nuclear stations represent the main obstacle to the use of nuclear energy, but its advantage is the amount of energy inherent in nuclear fuel, which makes the cost of producing kilowatt-hours very low compared to fossil fuels. Therefore, relying on nuclear energy to generate electricity has positive returns. Economical.



**Figure 13.** Selling price of electricity produced from different sources.

The following figure shows the price of electricity produced from nuclear energy compared to other energy sources. Traditional energy is still limited in production and high in cost when compared to nuclear energy, which is considered the cheapest energy source. The price of a kilowatt-hour produced from nuclear energy reaches 3.3 cents, while the price of electricity produced from oil and gas reaches 13-11.4 cents per kilowatt. (hour) respectively.

According to this vision, the security of nuclear energy in Egypt is one of the pillars of national security. That influence the mapping of global powers; The ability of any country is based on the availability of safe and sustainable energy sources, and thus it is a strategic matter and also reflects on achieving both food and water security for the citizens of any country.

Ensuring access to energy is one of the basic conditions for

continued economic development, and accordingly determines the size of this country's position on the global scene. For the rise of emerging powers on the international scene, the source of their strength lies in their economic growth, which needs energy sources to continue this growth and enhance their international standing.

We conclude from this chapter that most thermal power plants depend on fossil fuels in Egypt. Accordingly, the increase in oil prices made generating electricity expensive, in addition to financial complications for the government, and the electricity sector began to sink into a financial crisis due to the gap between supply and demand. One of the main reasons behind the failure of the electricity sector is insufficient installed capacity, and outdated stations, with transmission systems.

Incapable of management, poor financial management.



The shortage is due to the lack of significant investments and political instability, which has prevented the development of huge nuclear energy projects, increased dependence on expensive imported fuel and declining natural gas reserves, and, moreover, institutional shortcomings in the decision-making process that reduce and discourage private investment.

Since concerns about increased fossil fuel consumption and the consequences of greenhouse gas emissions have increased, greenhouse gas emissions have become a critical factor when constructing a power plant. This factor varies greatly along with the energy generation technology and the source used.

And it is clear from the study that nuclear facilities are a better option for reducing greenhouse gas emissions compared to fossil fuel plants. Hence, it is necessary to look for ways to source cheaper, reliable and secure sources of energy supply, and accordingly the government is focusing more on exercising good governance to secure energy and social and economic development in the future. Renewable sources, especially nuclear, are the actual solution to meet future challenges in Egyptian energy demands.

In contrast, despite the abundance of natural energy resources in Egypt, the country suffers from a lack of reliable and stable supplies of electricity. Because the demand for electricity far exceeds the supply; It is necessary to search for alternative forms of energy while continuing to increase the capacity of generation, transmission and distribution of current traditional energy sources.

through developing energy systems and policies that enhance social, economic and environmental performance. It has also been shown that there is a close link between nuclear energy and achieving the requirements of sustainable development, and therefore nuclear energy is considered one of the best options for meeting the electrical load requirements in Egypt.

Nuclear stations represent one of the most reliable applications in terms of environmental balance. The size of the amount of energy used in any country is an important indicator of economic size, quality of life and social development. Accordingly, the government is moving to design a sustainable policy. For economic growth. [16]

## 5. Conclusion

The search verifies that nuclear energy can contribute to solving the worsening electricity problem in Egypt, and to achieve economic stability and competitiveness in the international market, nuclear sources represent an essential element in future energy paths, developing electricity networks as an important element in the process of transition towards low-carbon systems, and developing The technological and institutional basis for a safe, large-scale, economically competitive nuclear power, whereby nuclear power supplies stable, high-quality electricity while reducing pollution in many developed and developing countries.

## Abbreviations

GW/H	Gigawatts Per Hour
KW	Kilowatts
MW	Megawatts
CO <sub>2</sub>	Carbon Emissions
\$	Dollar

## Author Contributions

Abeer Mohamed Abd Razek Youssef is the sole author. The author read and approved the final manuscript.

## Conflicts of Interest

The authors declare no conflicts of interest.

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## Biography



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