

# Green Technology and Alternative Energy Systems: A Case Study of Egypt with Special Emphasis on Sustainable Development

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## Abstract:

Since 2014, Egypt entered through several stages to reconstruct its economy, to adapt stabilization policies, and to modernize and expand its infrastructure base. This included establishing 30 new cities that are designed to utilize from 40 percent to 60 percent renewable energy within 10 years as part of the green strategy of Egypt. This was done with respect to a widespread geographical plan to cover all parts of the country. Egypt expanded on the agricultural sector and the fisheries with green technology practices and applications, including the New Delta Mega Project.

This was coupled by adapting several sustainable development practices in the industrial sector that included the 4 Rs of recycling, retrofitting, reuse, and reduce practices and applications

Egypt gave special attention to the green alternative energy systems by adopting wide practices of solar energy, wind energy, and hydroelectric energy generation projects.

These practices included the Benban Solar Park in Aswan which received the Annual Award as the World's Top Project by the World Bank in 2019. Also, Egypt added a new 580 MW onshore wind farm in the Gabal Al-Zait that is considered to be one of the largest wind farms in Africa. Egypt's largest hydropower clean energy plants are in Aswan, Esna, New Naga Hammadi, and Assuit.

This is accompanied by huge 120 sewage water recycling plants, using reverse osmosis filtration process, in several geographical locations across the country, including the sites of Bahr El Baqar Sewage Water Recycling Plant, and El-Gabal El-Asfar Sewage Water Recycling Plant to preserves the environment and support the Egyptian Sustainable Development Vision 2030.



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**Purpose:** This research paper attempts to study the adoption of the green technology as related to the alternative energy systems in Egypt in several sectors in the Egyptian economy to support the Egyptian national goals related to the Egyptian Sustainable Development Vision 2030.

**Design, methodology, and approach:** This paper focuses on studying the effects of the current ongoing plans of adopting green technology, as related to the alternative energy system in Egypt, on achieving sustainable economic growth levels to attain the goals of the Egyptian Sustainable Development Vision 2030 by reaching 22 percent green energy of the total energy generated in Egypt by 2030.

**Findings:** the analysis and results emphasized the followings:

1. There are several successful projects in different countries that adopted green technology as an alternative energy system. The exposure to such projects can enhance the Egyptian efforts in this connection.
2. Egypt can expand on regional green energy integration projects with neighboring countries. There are several joint projects already exists in this connection.
3. Egypt can expand on obtaining available international green energy funds from the World Bank Group and the European Investment Bank, in addition to the available regional funds from the African Development Bank.
4. Egypt has its own successful track record related to generating green solar energy, wind energy, and hydropower energy.

**The original value of the research paper:** It made recommendations and draw policies that can support Egypt’s sustainable development plan as related to the green energy technology as an alternative energy system to support Egypt Vision 2030 across the various Egyptian economic sectors.

**Keywords:** Recycling; Retrofitting; Reuse; Reduce; Benban Solar Park; Onshore Wind Farm in the Gulf of Suez; Hydropower Clean Energy Plants in Aswan, Esna, New Naga Hammadi, and Assuit; Bahr El Baqar Sewage Water Recycling Plant; El-Gabal El-Asfar Sewage Water Recycling Plant.

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## **1. Introduction**

Egypt is committed to Egypt Vision 2030 to attain sustainable development. Green technology and green energy are among the main priorities of the Egypt Vision 2030. Egypt is gradually transforming to green technology and green energy applications in the new cities and the new communities. Also, Egypt is promoting new incentives to attract users of green energy at the businesses and households’ levels. For example, some businesses and households transformed totally to the generate their solar energy needs, and they sell the excess solar energy to the Ministry of Electricity through the national integrated grid system. Egypt issued a special legislation for this purpose.

Egypt is one of the earliest countries that implemented green energy generation projects. According to Moussa (2013) Egypt is one of the earliest countries, especially in the Middle East and Africa, that utilized the hydroelectric power energy through the mega hydroelectric power energy project, which is the High Dam, in the 1960s. Over several decades, the Aswan High Dam protected Egypt from floods, and regulated the water supply for agricultural purposes, and for human needs.

According to the International Renewable Energy Agency – IRENA (2024) Egypt announced that share of the renewable energy to total energy, at the national level, will increase from 20% in 2022 to 42% in 2035 as part of Egypt’s sustainable development plans. Then, the Egyptian government announced more investments in the energy sector to increase the mentioned 42% to reach 60% renewable energy mix share to the total national energy generation. This shows that Egypt is working to exceed the targets of the Sustainable Development Strategy 2030 as regarding the adoption of the green technology and the alternative energy systems.

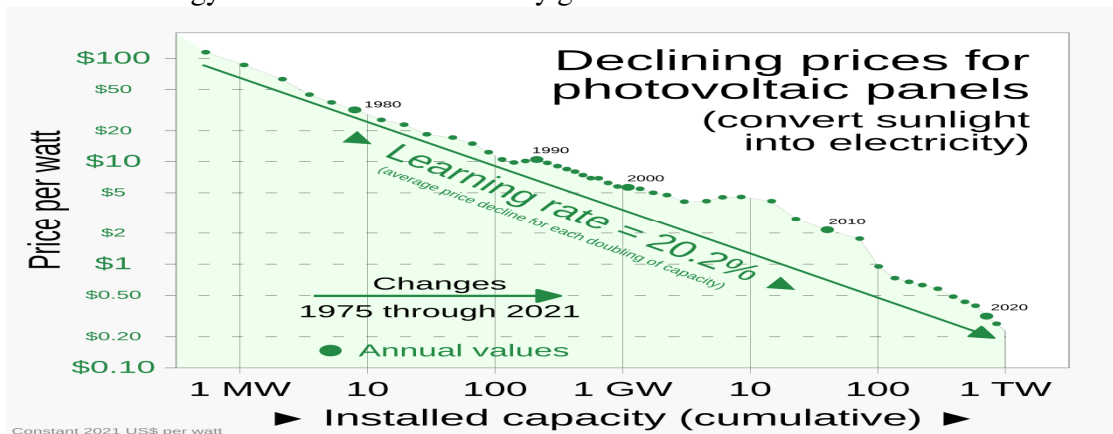
Also, Egypt established the New & Renewable Energy Authority (NREA) to provide Egypt with new energy technologies at a commercial scale.

This paper is divided into the following: Section one for the introduction. Section two for the literature review. Section three for green technology and alternative energy projects in Egypt to attain sustainable development. Section four for the econometric analysis of the relationship between the green technology and alternative energy projects in Egypt to attain sustainable development, and the economic growth in Egypt by using a time series analysis. Section five is dedicated for the conclusion, the findings, and the recommendations.

## 2. Literature Review

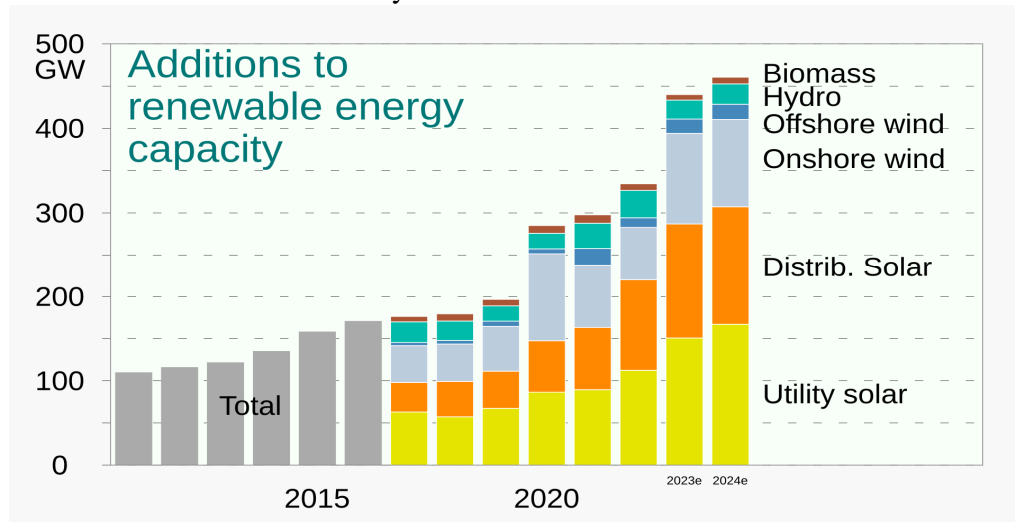
Armaroli (2022), Armaroli (2023), Deloitte Insights (2024), International Renewable Energy Agency – IRENA (2023), Lazard (2024), International Energy Agency- IEA (2020), Sensiba (2024), and Ehrlich (2018) specified that all renewable energy sources are considered to be green energy. Renewable energy includes solar energy, wind energy, geothermal energy, tidal energy, hydropower, and bioenergy. Most countries depend mainly on the solar energy, wind energy, and hydropower. The geographical and natural characteristics of each country play an important role in forming its mixture of renewable resources.

International Energy Agency- IEA (2021), Timperley (2024), Lockwood (2024), Susskind (2022), International Energy Agency- IEA (2022), Isaacs-Thomas (2024), Timperley (2023), Energy Institute Statistical Review of World Energy (2024), Friedlingstein (2024), Harjanne (2019), Kutscher (2024), and Srouji (2024) verified that world production and usage of the renewable energy became cost effective over the last 3 decades because of the rapid advancement in technology. This resulted in a decline in the international dependence on fossil-fuel based energy. The share of the fossil-fuel based energy out of the world total energy declined from 68% to 62%, and it is projected to continue declining to reach 58% by 2028. Many countries are replacing its heritage of fossil-fuel energy-based facilities with the new renewable energy facilities. Photovoltaic solar energy and onshore wind energy represent the cheapest replacement to generate electricity in most countries of the world. The International Energy Agency (IEA) estimated that the attainment of the world target to achieve net zero emissions in 2050, necessitates that share of renewable energy sources to total electricity generation to be 90% at least.



The Economist (2023), Abnett (2023), Overland (2022), Scovronick (2024), Wan (2022), Roberts (2023), Ramsebner (2024), and Energy Post (2024) verified that the transformation towards renewable energy and the alternative energy systems are still facing several constraints. Many businesses are lobbying to resist this transformation, and to avoid the cost of the transformation. There is an increasing trend to face these industries to avoid the damaging effect of the global warming. Recent natural disasters are clear examples of the damaging effect of the global warming.

Zhou (2024), Heilweil (2023), Schrottenboer (2022), and Lipták (2024) verified that almost 75% of the world countries are planning to triple their renewable energy dependence by 2030 as compared to the levels of 2020. The European Union (EU) announced its plan to exceed 40% renewable energy share in the total energy generated in the member countries by 2030 as well.



### 3. The Green Technology and the Alternative Energy Projects in Egypt to Attain Sustainable Development

Egypt over the last 10 years reconstructed its economy, by adapting stabilization policies, and by expanding its infrastructure base. Egypt established 30 new cities covering all parts of Egypt. These cities are currently utilizing 40 percent renewable energy, to be increased to 60 percent renewable energy within 10 years, as part of the green strategy of Egypt. Egypt expanded its the agricultural sector and its fisheries farms by using green technology practices and applications, including the New Delta Mega Project. Based on the Author field visits: Egypt implemented several mega projects to support its transformation into green technology and alternative energy systems as follows:

#### The New Delta Mega Project

The size of the New Delta Project is 2.3 million acres west of the old Nile Delta. The project is gradually transforming the dessert into green land. The project basically increased the size of the agricultural land in Egypt by 50% over the last 10 years only. Together with other agricultural and land reclamation projects, Egypt doubled its agriculture land over the last 10 years. These new green lands helped Egypt and the world to absorb higher quantities of CO<sub>2</sub> and CO<sub>1</sub>.

The New Delta Project is supported by lot of servicing industries, such as sorting, packaging, transportation, and agricultural manufacturing. Egypt is using high water treatment techniques to serve solely the irrigation requirements of these mega projects.



### The 4 Rs

There are several sustainable development practices in the industrial sector that included the 4 Rs of recycling, retrofitting, reuse, and reduce practices and applications. This represent a joint effort between the government, the businesses, and the civil society. One of these examples, is the Plastic Bank of Egypt that reduce and recycle plastic wastes of the industrial sector. The Egyptian Plastic Bank is encouraging individuals to exchange their plastic wastes for money and insurance. Also, there are several other institutions specialized on e-waste recycling to recycle electronics to save the environment from the hazardous waste, among them the GreenPlace eWaste Recycling.



### Benban Solar Park in Aswan

The Benban Solar Park in Aswan is in the western desert and located 40 km from Aswan. The Benban Solar Park in Aswan received the Annual Award as the World's Top Project by the World Bank in 2019. Benban is currently the first largest clean solar power plant in the world in terms of electricity generation, and the 4th when it comes to storage. This huge solar park is composed of 41 plants over 37.2 km<sup>2</sup>.





### **Onshore Wind Farm in the Gulf of Suez**

Zafarana Wind Farm is the oldest wind farm in Egypt. Egypt added a new onshore wind farm in the Gulf of Suez, and a new 580 MW wind farm in Gabal Al-Zait with 110 turbines that is considered to be one of the largest wind farms in Africa.



### **Hydropower Clean Energy Plants**

Egypt's largest hydropower clean energy plants are in Aswan, Esna, New Naga Hammadi, and Assuit. These are sustainable hydropower energy plants located in upper Egypt (south of Egypt).



**Sewage Water Recycling Plants**

This is accompanied by huge 120 sewage water recycling plants, using reverse osmosis filtration process, in several geographical locations across the country, including the sites of Bahr El Baqar Sewage Water Recycling Plant, and El-Gabal El-Asfar Sewage Water Recycling Plant to preserves the environment and support the Egyptian Sustainable Development Vision 2030. Bahr El Baqar Sewage Water Treatment Plant, with its pumping stations and water carriers, is considered to be the largest worldwide wastewater treatment plant.



**4. The Econometric Analysis of the Relationship Between the Green Technology and Alternative Energy Projects in Egypt to Attain Sustainable Development, and the Economic Growth in Egypt by Using a Time Series Analysis**

**Data Analysis**

Data collected dealt with economic growth represented by the Egypt’s GDP growth, against the green technology and alternative energy projects to attain sustainable development over 5 years divided into interims.

$$Y = \beta^0 + \beta 1 AIS + \mu$$

The annual GDP growth is the dependent variable while the rest of the variables are explanatory variables. The main explanatory variable is the green technology and alternative energy projects in Egypt and other variables are used as stochastic error term.

Y	GDP growth (Annual %)
GGTAEP	The Growth in Green Technology and Alternative Energy Projects in Egypt

The relations are tested by Auto-Regressive Distributive Lag model.

- **Unit root test**

Before running the model, Unit root test is applied to ensure that all the variables are either I(0) and I(1) in order to avoid spurious regression.

Variable	Prob.*	
	At level	1 <sup>st</sup> difference
GDP growth	0.00482	0.0000
GGTAEP	0.917	0.0000

**ARDL Model**

Included observations: 44 after adjustments  
 Maximum dependent lags: 3(Automatic selection)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
GDP_GROWTH(-1)	0.006392	0.754698	0.051324	0.6927
GGTAEP	0.004351	0.008913	0.689734	0.5546
R-squared	0.571669	Mean dependent var	4.293301	
Test Statistic	Value	k		
F-statistic	0.725588	4.7		

This is a case of positive correlation. In the long run the GGTAEP sector growth proved to have a significant positive effect on the economic growth in Egypt matching with the economic theory that the advancement and the long-run cost decline in the green technology and the alternative energy systems will ultimately lead to accelerate economic growth.

**4. Conclusion, Findings, and Recommendations**

The advancement of the technology and international cooperation in Egypt accelerated the access to the new green technology and the alternative energy.

The econometric analysis of the relevant data proved a positive correlation between the growth in the Egyptian green technology and the alternative energy projects and the growth in the Egyptian economy.

The followings are few recommendations made to Egypt to expand on its sustainable development plans connected to the utilization of green technology and the alternative energy systems:

1. There are several successful projects in different countries that adopted green technology as an alternative energy system. The exposure to such projects can enhance the Egyptian efforts in this connection. Egypt can implement this easily based on its experience gained from organizing the COP27.
2. Egypt can expand on regional green energy integration projects with neighboring countries. There are several joint projects already exists in this connection. Arab Gulf countries are also having sustainable development strategy. This could be an excellent base for cooperation.



3. Egypt can expand on obtaining available international green energy funds from the World Bank Group and the European Investment Bank, in addition to the available regional funds from the African Development Bank. The international development institutions, and the regional development institutions allocated huge funds for this purpose. For example, the European Union (EU) together with many donors established the Loss & Damage Fund during the COP27 in Egypt. The Loss & Damage Fund was created to transform funds from the developed countries to the developing countries as a compensation for the environmental damage caused by the industrial practices, especially as related to the CO<sub>2</sub> emissions.
4. Egypt has its own successful track record related to generating green solar energy, wind energy, and hydropower energy. Egypt can provide its relevant experience to expand regionally in the transformation towards green energy to attain regional sustainable development.

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