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The Feasibility of Egypt's Photovoltaic Industry Drawing on China's Successful Experience

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Abstract: This study aims to evaluate the feasibility of Egypt's photovoltaic industry drawing on China's successful experience. Firstly, based on Egypt's national conditions and actual situation, the current situation, development potential, and challenges faced by the Egyptian photovoltaic market were analyzed.Egypt's economic foundation remains less competitive, with outdated electricity infrastructure and long-term dependence on natural gas, posing challenges to its transformation. Egypt is one of the regions with the most concentrated solar energy resources in the world, which gives it the possibility and new opportunities to overtake in the photovoltaic field. Secondly, by analyzing the development process of China's photovoltaic industry, this paper explores China's successful experiences in policy support, market demand, technological level, financial support, and talent cultivation.Compared with China, Egypt's photovoltaic industry is still in an underdeveloped and developing stage, and requires sustained efforts in multiple aspects. This article compares the significant differences in the development of photovoltaic industries between China and Egypt, and analyzes the opportunities and challenges faced by Egypt's photovoltaic industry, as well as the corresponding strategies from three aspects: policy stability, demand activation, and desert photovoltaics. Finally, based on the research results, policy recommendations and development paths are proposed to promote the development of Egypt's photovoltaic industry, to provide reference and inspiration for the sustainable development of Egypt's photovoltaic industry.

Keywords: photovoltaic industry, Egypt, China's experience, comprehensive sustainable energy strategy, desert photovoltaics

1. Introduction

1.1. Background

In terms of power generation capacity, Egypt ranks first in the African continent. Besides, From the perspective of power grid construction, the Egyptian power grid has achieved full coverage, sufficient to meet the electricity needs of every household. Moreover, from the perspective of power generation types, Egypt's electricity supply is mainly based on natural gas power generation. According to Fitch Solutions data, Egypt generated approximately 196.2 TWh of electricity and consumed approximately 161.8 TWh of electricity in 2021, resulting in an oversupply of electricity. In terms of energy structure, natural gas power generation accounted for 77.6% in Egypt in 2021, hydroelectric

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power generation accounted for about 6.5%, and renewable energy power generation only accounted for 3.4%.

Egypt is a major producer and consumer of oil and gas in Africa. Since the 1970s, Egypt's natural gas production and consumption have maintained a synchronous growth trend, and exports have been increasing year by year since 2004 [1]. Natural gas is an important industry supporting the Egyptian economy, accounting for over 10% of GDP and a significant source of export earnings. In the fiscal year of 2021-2022, Egypt's natural gas export revenue was 8 billion US dollars, and the natural gas export volume increased 13 times in 8 years. Egypt's liquefied natural gas export growth rate ranked first in the world.

Currently, Egypt is facing a relatively severe debt crisis. As of the end of June 2023, the ratio of Egyptian government debt to GDP has reached 97% [2]. Therefore, Egypt needs to export more natural gas in exchange for more foreign exchange urgently. Moreover, the aging of equipment in Egyptian power plants has led to insufficient power generation capacity. Further, the continuous increase in exports of natural gas to Europe and surrounding countries has reached a considerable extent that caused periodic shortages of natural gas supply to domestic power plants, resulting in frequent power outages in various regions of Egypt during the scorching summer.

In summary, although the overall electricity supply in Egypt has a surplus, the domestic electricity supply is facing structural shortages due to the increased natural gas exports and a single-power energy structure. So, all in all, green energy power generation seems to be an ideal solution. And can ease the burden of electricity.

1.2. Energy Transformation

It is a wise choice for Egypt to build a green and low-carbon new power system with natural gas power generation as its main source, and renewable energy as its supplement energy source. In photovoltaic power generation systems, the cost of components accounts for two-thirds of the total cost, so the cost of components directly affects the comprehensive cost of power generation. The International Energy Agency predicts that by 2025, the world will almost entirely rely on China's supply of key components for the production of photovoltaic panels [3]. After 2009, the production cost of photovoltaic enterprises in China significantly decreased, bringing the era of “one RMB” photovoltaic power generation ahead of schedule. It is also an important turning point for the development of the photovoltaic industry in third-world countries. The preparation of silicon materials and the production of silicon wafers in the upstream end of the photovoltaic industry usually require a large amount of electricity consumption. Therefore, only by reducing the cost of electricity can the production cost of silicon materials and silicon wafers naturally decrease. Thanks to the arduous entrepreneurship of Chinese photovoltaic enterprises, the global photovoltaic cost has decreased by more than 85% in the past decade, making it the most competitive clean energy in the world [4]. To sum up, China’s success can provide valuable experiences for Egypt’s crisis.

Compared to natural gas power generation, the cost of photovoltaic power generation mainly includes equipment procurement and silicon wafer production, with relatively lower subsequent operation and maintenance costs.

After years of development, the cost of solar photovoltaic power generation has significantly decreased by more than 90%. The cost of photovoltaic power generation has been rapidly decreasing, and in some markets, it has become equally competitive with coal, natural gas, and land sea wind power generation [5].

Bloomberg New Energy Finance data shows that the capital return rate of photovoltaic projects in Egypt is 10-11%, making Egypt one of the countries with the lowest cost of photovoltaic and onshore wind power globally [6]. These researches show that the photovoltaic perspective is bright and may reduce their energy cost, which can ultimately promote their economic development.

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1.3. Energy Transformation

The International Renewable Energy Agency predicts that by 2050, renewable energy generation will account for 85% of electricity, with 60% coming from photovoltaic and wind power [7].

Egypt has abundant photovoltaic resources. According to the Global Solar Atlas, the main sunny areas in Egypt have an effective annual sunshine duration of over 2400 hours.Egypt's goal is to achieve a renewable energy share of approximately 42% by 2035, with photovoltaics accounting for 21.3% [8].

The reason why Egypt has launched a comprehensive sustainable energy strategy is to achieve the early replacement of traditional fossil fuels with renewable energy, minimize the proportion of traditional energy such as petroleum and chemical, and maximize the proportion of renewable energy represented by photovoltaics.

2. Changes in Egypt's electricity supply structure over the next five years

2.1. Optimization of Power Energy Structure

Since 2011, Egypt has frequently faced social problems of power supply shortages. After 2014, Egypt gradually increased its special investment in the field of hydropower, which to some extent solved the problem of electricity shortage. However, the problem of excessive reliance on natural gas power generation has become increasingly prominent. Egypt repeatedly proves that the imbalance of the power energy structure directly affects the stability and the sustainability of the power ecosystem.

On June 5, 2012, Egyptian Minister of Electricity and Energy Yonis revealed that the Egyptian power sector has formulated a 15-year plan to vigorously develop solar photovoltaic power generation, intending to increase Egypt's solar photovoltaic power generation capacity to around 20% of total electricity demand by 2027.

Another more specific goal for Egypt is that by 2040, renewable energy generation will account for 60% of Egypt's total electricity generation.According to third-party predictions,The photovoltaic industry in Egypt is accelerating its development, with a planned installed capacity of 43 gigawatts(GW) by 2035 [9].

From 2024 to 2029, Egypt's overall power generation will maintain a slight steady increase, with an expected growth rate in the range of 3% -5%, and natural gas power generation will remain the main form. Nowadays, Egypt has become one of the important sources of natural gas supply to the European continent. In the next five years, Egypt's natural gas exports are expected to continue to maintain a high growth model.With the acceleration of new energy development, Egypt has become the second largest market for new energy development in the African region [10].Egypt will still utilize natural gas more for exports rather than power generation, to alleviate its debt burden. This paragraph detailly suggests the structure change of Egypt’s power energy.

3. The Successful Model of Desert Photovoltaics in Xinjiang Province

3.1. What is desert photovoltaics?

Egypt has a desert area of 950,000 square kilometers. 95% of its land area is desert. The province with the largest desert area in China is Xinjiang, with a desert area of 440,600 square kilometers, accounting for 64% of China's desert area.

Xinjiang, an economically underdeveloped region in China, has achieved commendable results in promoting desert governance, ecological protection, and industrial development through photovoltaic coordination. The development model of desert photovoltaics in Xinjiang is worth Egypt's reference and reference.

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Taking Xinjiang's desert photovoltaics as an example, photovoltaic power stations are usually built on the edge of deserts.Vigorously developing desert photovoltaics, utilizing photovoltaic panels to produce green energy through "on board power generation, inter board sheep farming, and under board grass planting", and achieving positive interaction [11]. Nowadays, in the desert areas of Xinjiang, China, solar panels with a height exceeding 2 meters have become the preferred choice for wind protection and sand fixation. Compared to various vegetation typically over 30 centimeters in height, the wind and sand fixation effects of solar panels are improved by at least four times. Based on this, plants such as thorns, sand grass, shuttle, and jujube trees are planted under the solar panels to prevent wind and sand fixation. Poultry is raised under solar panels, and poultry manure naturally becomes a natural fertilizer for wind and sand fixation plants. Using photovoltaic to control sand, planting grass to fix sand, and raising poultry to plant greenery, can effectively control barren deserts. A photovoltaic power station built in the desert can stably transfer considerable electricity to the outside, achieving a dual harvest of social and economic benefits, forming a virtuous cycle of "photovoltaic power generation+ecological agriculture+desert restoration".

3.2. Recommendations

To achieve Desert photovoltaic, planning and construction are the focus, transmission and operation are the key, and talent introduction and training are the core. The construction of desert photovoltaics in Egypt must address these three issues. Otherwise, we will face the dilemma of low operational efficiency and the difficulty in transmitting electricity resources to the outside world.

The focus of desert photovoltaics is to solve the practical problems of where money comes from and how the industry develops. As the most renowned policy bank in China, the China Development Bank has established a market-oriented grid connected photovoltaic power generation project infrastructure fund in Xinjiang. In addition, the National Electronic Development Fund has greatly promoted the development of the photovoltaic industry in Xinjiang, the landing of the photovoltaic industry in Xinjiang and cultivated professional talents with the ability to operate and maintain photovoltaic power stations. Two polysilicon companies in Xinjiang have become one of the world's lowest production cost polysilicon companies [12].

Photovoltaics is a key green energy industry supported by Egypt. Xinjiang is a good model to emulate. It is suggested to build a complete photovoltaic industry chain, to introduce powerful enterprises to build desert photovoltaic industry parks, to form photovoltaic industry clusters with Cairo and Aswan as the core cities, to accelerate the planning, construction, and operation of photovoltaic bases based on the Gobi, desert, and desert. Taking desert photovoltaics as the starting point, to efficiently manage the desert, improve people’s long-term livelihoods, promote the economy, and reconstruct Egypt's energy structure.

4. China's Experience and Lessons Learned

4.1. Policy Stable is Essential

The investment return cycle of the photovoltaic industry is about 10 years, and the stability of policies is the main reason for the flourishing development of the photovoltaic industry in China, the United States, and Germany. The instability and discontinuity of policies are the biggest obstacles to the development of the photovoltaic industry in Egypt. The stability of industrial policies in Egypt is poor, especially at the implementation level. Private and corporate photovoltaic power generation policies, photovoltaic power generation subsidy policies, tax relief, preferential electricity purchase, etc. All policies to promote the development of the photovoltaic industry should be consistent and sustainable.

Egypt's policies supporting the development of the photovoltaic industry mainly reflect the provision of cheap land and tax incentives. Egypt's development of the photovoltaic industry requires

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a holistic consideration of the four aspects of supply, demand, market, and industry, and the formulation of policies that give enterprises and industries more confidence in the photovoltaic industry. Legislation as a guarantee, policy-driven, and demand-oriented, are inevitable requirements for the development of the photovoltaic industry. The feed-in tariff and the feed-in agreement all need to be confirmed by the rule of law.

Enterprises participating in the construction of desert photovoltaic industrial parks can be given no less than 20% of project cost support and related financing support. The Egyptian government should formulate a five-to-ten-year plan for the development of the photovoltaic industry. Egypt should follow the example of Xinjiang in China, and continue to promote the development and construction of new energy projects based on desert photovoltaics in the deserts and Gobi regions in the northern and southern regions.

4.2. Activating Demand is a Key Priority

In the years before 2010, China's photovoltaic industry faced a paradox, strong local government drive and weak domestic market demand. Relying on external demand and weak domestic demand is a lesson for the development of China's photovoltaic industry. The key to the development of Egypt's photovoltaic industry lies in activating domestic market demand. Egypt's domestic electricity price is on the rise, and increasing subsidies for photovoltaic electricity consumption will help the public and enterprises turn more to clean energy. Implementing tiered electricity prices, the more photovoltaic electricity consumers use, the more subsidies the government will provide. For residential users, a subsidy of 0.5 Egyptian pounds per kilowatt-hour will be given for electricity consumption of 0-200 kilowatt-hours per month, and a subsidy of 0.8 Egyptian pounds per kilowatt-hour will be given for electricity consumption of more than 200 kilowatt-hours per month. For commercial users, a subsidy of 0.7 Egyptian pounds per kilowatt-hour will be given for electricity consumption of 500-1000 kilowatt-hours per month, and a subsidy of 0.8 Egyptian pounds per kilowatt-hour will be given for electricity consumption of 1000-2000 kilowatt-hours per month.

The subsidy policy will last for five years, and the subsidy amount will remain at a 20% increase every year. Residents and businesses using photovoltaics will be granted personal income tax and tax deduction and exemption, while increasing the intensity and breadth of consumer loans and production loans to residents and businesses using photovoltaics. Following the experience of the United States and China, Egypt implemented incentives to support photovoltaic consumption, supported net-metering photovoltaic projects, and avoided the embarrassment of selling electricity at low prices and taking electricity from high-priced grids, so that residents can obtain more real benefits from using photovoltaics.

There are both electricity price subsidies and installation subsidies, which guide ordinary people to join the photovoltaic roof plan and encourage ordinary farmers to build and install photovoltaic power plants. This is a typical subsidy demand-side behavior. The greater benefits of the public joining the photovoltaic roof plan and building and installing photovoltaic power plants are reflected in the savings of daily electricity expenses, and the surplus electricity can be sold to the national power grid to obtain tangible benefits.

4.3. Advocating Industry Integration

The prominent problem of Egypt's photovoltaic industry is "small and scattered, scattered and chaotic". The market share of enterprises above the designated size in Egypt's photovoltaic power generation industry is around 10%. The industry entry threshold is not high, the regional distribution is scattered, the homogenization competition is serious, and the low-price internal consumption is obvious, resulting in poor comprehensive competitiveness of Egypt's photovoltaic industry. Egypt

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lacks large-scale and high-quality photovoltaic manufacturing capacity, mainly relying on imported equipment or introducing enterprises to meet the increasing demand for photovoltaics. The photovoltaic industry in Egypt is still in its early stages,There are relatively few local personnel with relevant experience and technology [13].

Industry consolidation is the direction and trend of the development of Egypt's photovoltaic industry. Egypt should adhere to the principle of "market for technology, market for development" in the process of attracting well-known photovoltaic enterprises from China through investment promotion. Small and medium-sized photovoltaic enterprises in Egypt can provide industrial support for Chinese photovoltaic enterprises. Chinese photovoltaic enterprises can provide support for small and medium-sized Egyptian photovoltaic enterprises in technology research and development, skills training, business incubation, manufacturing, etc., expand and enhance the product structure, added value and technological content of small and medium-sized Egyptian photovoltaic enterprises, and promote the integration and overall upgrading of Egypt's photovoltaic industry.

4.4. Embracing Marketization as the Path Forward

The photovoltaic industry is highly competitive, and the marketization of the Egyptian photovoltaic industry is a trend. Due to the particularities of Egypt's economic development, the power industry, including the photovoltaic industry, still belongs to the monopoly nature of administrative dominance, resulting in the strange phenomenon of being both rule makers and industry participants. Opening up to the outside world and liberalizing within the country. To develop the photovoltaic industry, we should allow more private enterprises to participate in it, give them more policy support, and make "government guidance and market leadership" the underlying logic of the development of the Egyptian photovoltaic industry.

5. Conclusion

5.1. Personal observations

In February 2023, I was awarded a full scholarship for the AFS STEM academic camp for middle school students. From July 20th to August 17th, I went to Egypt to participate in the 2023 AFS STEM international cultural exchange program for middle school students and visited BP Egypt in the UK. During Egypt, there were frequent nighttime power outages, which triggered my thoughts on the development of Egypt's electricity supply, especially the photovoltaic industry.

Due to time and space limitations, this article is mainly written in the form of reading literature and conducting online interviews. Due to the lack of detailed data support, this article's estimation of Egypt's photovoltaic power supply for the next 5 years is not precise or precise enough.

5.2. The overall structure

This article reflects on the development of China's photovoltaic industry, which can help Egyptian government departments learn from it in policy formulation and industry promotion. During 2009, China's photovoltaic industry experienced problems such as oversupply, market failure, and government failure due to distorted local government performance views and rapid growth. In 2009, the global financial crisis broke out, and the photovoltaic industry became a key engine driving China's economic growth. In the field of photovoltaics, the Chinese government has introduced strong stimulus measures, and the Chinese Ministry of Finance has stipulated that grid connected photovoltaic power generation projects will be rewarded with 50% of the total system investment in that year [14].Since 2013, the domestic photovoltaic application market in China has truly started and rapidly exploded [15].Therefore, it is necessary to confirm the role and effectiveness of the market

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and policies in the development of the photovoltaic industry. Policy guidance and market leadership are the feasible strategies to promote the healthy development of the photovoltaic industry.

The future research on the photovoltaic industry will always focus on both demand and supply. Whether to pursue a demand oriented photovoltaic policy or adhere to a supply oriented photovoltaic policy depends on a country's economic development needs. From the experience of the development of photovoltaic industry in various countries, it can be seen that adhering to fully differentiated market competition on the supply side is more effective, while the demand side requires active guidance from subsidy policies that can be implemented and withdrawn.

With the adjustment of energy structure, China is striving to transform from an energy importing country to a clean energy exporting country [16]. Due to a lack of core competitiveness, China's photovoltaic industry suffered an avalanche in 2012. By 2015, China's photovoltaic industry not only had independent technology, but also controlled a huge domestic market [17]. The focus of this article is to analyze the successful practices and lessons learned in China's development of the photovoltaic industry, and based on this, to analyze the opportunities, challenges, and actions of Egypt's development of the photovoltaic industry. To open up to the outside world and to open up domestically, only by opening up to the outside world can Egypt's photovoltaic market continue to grow. Only by opening up domestically can Egypt's photovoltaic demand become increasingly prosperous, thus forming a Pareto optimality. In the photovoltaic field where cooperation between China and African countries is deeply mature, China has accumulated a good reputation [18]. Egypt can emulate and learn from China's approach of "policy guidance, enterprise leadership, and demand being king" in the high-quality development of the photovoltaic industry.

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