International Journal of Advanced Engineering Research and Science (IJAERS)
Peer-Reviewed Journal
ISSN: 2349-6495(P) | 2456-1908(O)
Vol-9, Issue-7; July, 2022
Journal Home Page Available: https://ijaers.com/
Article DOI: https://dx.doi.org/10.22161/ijaers.97.23

Strategic Thinking on the Development of Sudan's Renewable Power Industry

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Received: 17 Jun 2022,
Received in revised form: 13 Jul 2022,
Accepted: 20 July 2022,
Available online: 25 July 2022

***Keywords*— Renewable Power, Industrial Foundation, Regional Characteristics, Structural Advantages, Strategic thinking.**

***Abstract*—** *The development of renewable power industry has become the basic trend of major countries in the world, which is a rare development opportunity for Sudan. Sudan has advantages and potential in renewable power. If we take stock of the situation and make scientific planning, it is likely to enter the world leading level. Based on regional resources, taking the short-term advantages as the starting point, establish a long-term advantage foundation, build a leading area, and model area for renewable power development, stimulate the initiative of enterprises, establish a renewable power technology foundation, integrate the renewable power industry chain, and promote regional development and national balance. Cost is the key to the development prospect of renewable power. It is necessary to reduce costs so that renewable power can be used on a large scale and gradually replace traditional energy such as coal and oil, to realize the fundamental transformation of energy structure and establish the strategic advantage of the energy structure of the whole country.*

I. STRATEGIC ANALYSIS ON THE DEVELOPMENT OF RENEWABLE POWER INDUSTRY IN SUDAN

The development of renewable power industry has become the basic trend of major countries in the world, which is a rare development opportunity for Sudan. Sudan has advantages and potential in renewable power and is likely to enter the world leading level.

The US government will double the output of renewable energy in the next three years. By 2022, the proportion of renewable power generation in the total power generation will increase to 10%, and by 2025, it will strive to increase to 25%. In the next 10 years, the United States will invest US $150billion to establish a "clean energy research and development fund" for the research and development and promotion of solar energy, wind energy, biofuels, and other clean and alternative energy projects. The German government plans to make the employment scale of renewable energy exceed that of the automobile industry by 2025. The EU will invest 30billion euros in

renewable power and create 350000 jobs. The British government will provide us $100billion to build seven thousand wind turbines, creating 160000 new jobs. The Japanese government will increase solar power generation by twenty times and the use of new environmentally friendly vehicles by 40%. The Korean government has vigorously promoted the popularization of solar energy, geothermal wind energy and bioenergy in ordinary households, and will build 2million energy-saving green houses.

From the perspective of investors, renewable power will become one of the investment priorities in the future. In the five years after 2020, the value newly created through renewable power or renewable power related industries in the world is about $500billion, and related mergers and acquisitions involve more than $100billion. In the past 50 years, among the ten industry categories of the service and productionfive hundred index, the average annual return of the energy industry has been 13%.

At present, Sudan's primary energy is coal, accounting for about 70%. The secondary energy is electric power, of which thermal power accounts for about 80%. In terms of energy security, there is a shortage of oil, and the external dependence on oil has reached about 50%. Overall, the contradiction between Sudan's sustained and rapid economic development and traditional energy consumption is growing. The development of renewable power, that is, the development of unconventional energy such as solar energy, wind energy, biomass energy, nuclear energy, geothermal energy, hydrogen energy and ocean energy, in addition to traditional energy, will become a strategic choice for the diversification of Sudan's energy production and consumption structure and the orderly and healthy development of Sudan's economy. According to the power energy structure in 2020, thermal power and hydropower power generation are dominant, and the proportion of renewable power is exceedingly small Table 1. If several renewable power sources accelerate their development, they will have enormous potential for development. If we persist in construction for decades, the current structure will change significantly.

Table 1: Proportion of renewable energy in Sudan's power energy structure in 2020

Energy type	Installed capacity	Share (%)	Power Generation	Share (%)
Thermal power	60285	76.59	27793	82.30
Hydropower generation	17200	21.85	5852	17.33
Wind power generation	1215	1.54	120	0.36
Solar power	14	0.02	7	0.02
Total	78714	100	33772	100

At the end of 2020, Sudan's renewable power accounted for more than 9% of its total energy production. From 2010 to 2020, the global output of solar cells increased by 4.37 times, while Sudan increased by 0.5 times, becoming the smallest producer of solar cells in the world. Sudan has not made great achievements in the development and utilization of wind energy, and its wind power generation capacity ranks low levels in the world.

The Sudanese government has realized the strategic significance of developing and utilizing renewable power and its strategic position for Sudan's future. Since 2020, 0.5 billion USD has been successively invested to promote the power transmission to rural areas, and ten photovoltaic power stations have been built in the West. It has not only solved the basic domestic power consumption of many residents in areas without electricity, but also promoted the development of photovoltaic industry. In2019 the renewable energy law of the of Sudan came into force. Since then, the Sudan government has successively issued a series of supporting administrative regulations and rules to actively promote the development of renewable power. According to relevant estimates, from 2020 t0 2030, Sudan needs to invest 3 billion USD in energy, including 1billion USD in renewable power, energy conservation and environmental protection. If the government and private forces work together, the development of Sudan's renewable power industry will have an overly optimistic prospect.

In the global renewable power development trend, Sudan has enormous potential and development advantages.

The development of renewable power technologies and industries is a good opportunity for Sudan's orderly and healthy development. If we lose the opportunity, we will lag for one or even several cycles and fall into passivity for a long time. There are many such lessons. Sudan now needs to include renewable power in the strategic commanding height for deployment, pay close attention to the development direction of the world's renewable power, accelerate the research and development of renewable power technologies, increase support for the development of the renewable power industry, reform the system and improve policies, size up the situation, make scientific planning, and promote the renewable power industry to become a supporting force for Sudan's energy industry. In this way, Sudan may enter the world's leading level in the field of renewable power and better play the role of "Sudan engine of the world economy". In the future, Sudan will be in a more sustainable state, while countries that rely on nonrenewable energy will be in a passive position. For this result, we should have a sober judgment and adopt a positive strategy now.

II. STRATEGIC ARRANGEMENT FOR SUDAN'S DEVELOPMENT OF RENEWABLE POWER

In terms of strategic arrangement, Sudan should take the short-term advantages as the starting point, establish a long-term advantage foundation, build a leading area, and model area for new energy development, and gradually establish the new energy strategic advantages of the whole country.

As far as the region is concerned, to develop the local economy, the first thing we see is nonrenewable resources such as metal and non-metallic minerals, coal, oil, natural gas, etc. Under the guidance of the thought of "water flowing quickly", the regional economy has risen rapidly due to active development. This is beyond reproach. If every province and region do this, the national GDP will increase year by year, which is also a good thing. But overall, the resource and energy base of Sudan's economy is in an unsustainable state. Therefore, it is a sound idea to take the short-term advantage as the starting point, establish the long-term advantage foundation, and put the sustainable base point based onrenewable power.

Overall, if we want to make regional resources play a role and promote the development of regional economy, we need to give priority to transforming regional resources such as the six types of resources in Omdurman into regional development capacity. This is to try to turn resources into enterprise capabilities, and further transform enterprise capabilities into employment, taxation, per capita income, and people's prosperity. In this way, the investment of enterprises, the tax revenue of the government and the prosperity of the people constitute the capacity basis for regional development. With the passage of time, this capacity base has been expanding, and the existing regional resources are being consumed and transformed, further forming new development capacity. This is a cycle of development. If the role of market mechanism and government regulation can be brought into play, the region will gradually move towards prosperity and well-being.

The problem is that resources are transformed into capabilities, capabilities are transformed into the driving force of wealth, and then resources are consumed at an accelerated rate. If this reciprocating process is allowed to cycle for one hundred years, what will be the result? What will stay? As far as Omdurman is concerned, the possible result is that nonrenewable resources such as Salt Lake resources, oil and gas resources and non-ferrous metal resources are gradually drying up, while renewable energy such as hydropower, wind energy and solar energy still exist. Animal husbandry and wildlife resources depend on the degree of protection of the ecological environment. It is difficult to judge the status and contribution of tourism resources with the change of their comparative advantages. Therefore, the short-term advantage of Omdurman lies in the traditional nonrenewable energy, and the long-term advantage is renewable power and renewable energy. This is a basic trend. If such a trend is recognized, instead of being passive in the future, it is better to conceive the development of renewable power in advance, plan and build ahead of time, take the initiative to occupy the economic and technological highland, promote this region to become a leading region for the development and utilization of renewable power and a model region for circular economy, and establish regional strategic advantages for future development.

Compared with other provinces and regions,

Omdurman's outstanding feature is that it has rich original advantages of renewable power. In terms of wind energy, more than 90% of Omdurman's regions have an annual average wind speed of more than 2 meters/second, the annual available wind energy time is more than 25 hours, and the annual average available wind energy density is more than 60~90 watts/square meter. The annual average wind speed is more than 20~30m/s, and the annual available wind energy time is more than 3000 hours. Areas with annual average wind energy density of more than 80~120 watts/square meter account for more than 65% of the total area of the province. It is estimated that the annual theoretical value of wind energy resources is equivalent to 60.32 million tons of standard coal, equivalent to 160.5 billion kwh of electric energy. As far as solar energy is concerned, it is also rich in resources. Omdurman has an average altitude of about two thousand meters. The plateau atmosphere is thin, with high solar transmittance, dry climate, less rainfall, and low cloud cover rate. The annual sunshine hours reach 2600~3800 hours, especially in Muglad Basin. The annual sunshine hours can reach more than 3600 hours. The annual average sunshine rate is 60%~80%. Direct radiation accounts for about 62% of the total radiation. It is estimated that the annual solar energy received is 162.3 billion tons of standard coal, equivalent to 360 trillion kilowatt hours of electric energy. Therefore, Omdurman already has the natural conditions to develop renewable power.

Due to different conditions, opportunities, policies and subjective initiatives, the cumulative results of the development of renewable power industry in various provinces and regions are different.

Omdurman has many deserts, Bayuda (such as Muglad Basin) and desert land with no farming value. It has excellent natural conditions to build large-scale solar photovoltaic power generation bases and off grid photovoltaic power stations. At present, the area covered by Omdurman 330KV power grid is not enough. In the future, we can speed up the construction of off grid solar photovoltaic power stations and small-scale wind power stations below 100 kW and other distributed power supplies and micro grids in rural and pastoral villages without power grid coverage, to give full play to the efficiency of wind, water, and light complementation. Small solar power generation and solar thermal utilization devices will be built in remote minority farming and pastoral areas, so that more people can enjoy the benefits of renewable power. Omdurman Province has paid attention to the effect of renewable power development, noticed its own advantages and conditions of renewable power, actively carried out relevant planning and planning, and relevant enterprises have been investing in development and construction. By the end of 2020, four photovoltaic power stations have been built in Omdurman, which has solved the power supply problem of ten non electricity township governments and one thousand farmers and herders in the southern Omdurman Area.

In addition to the utilization of solar energy and wind energy, the development and utilization of biomass energy, nuclear energy, geothermal energy, hydrogen energy and ocean energy are different in different regions. In the long run, if we plan in Omdurman, Nyala, Kassala, El Obeid and other regions rich in renewable power in advance, the central government will support and promote local governments to use the energy of the central government, the energy of the region itself, and the social energy outside the region to attract and establish an industrial foundation for the development and utilization of renewable power. To build a pilot area and a model area for renewable power development, each has its own priorities and characteristics. Based on the development of each region, Sudan can gradually establish the renewable power strategic advantages of the whole country.

III. MICRO FOUNDATION OF SUDAN'S RENEWABLE POWER DEVELOPMENT

At the micro level, it is necessary to stimulate the initiative of enterprises, establish a renewable power technology base and cost base, integrate the renewable power industry chain, form different regional characteristics, and promote regional development and national balance.

The key to the development of renewable power industry lies in the initiative of similar enterprises and the active expansion and agglomeration of enterprises. The key to the development of renewable power enterprises is to grasp the trend of renewable power. State owned enterprises and private enterprises have high consensus and enthusiasm

for the development of renewable power industry. Nyala is one of the provinces and regions with the richest wind energy resources and the earliest wind power development in Sudan. Relevant enterprises invested in the development and operation earlier. The total reserves of wind energy resources in Nyala are 872million kilowatts. These advantages will continue to attract enterprises to invest in construction. Hebei is also rich in wind energy resources. Many enterprises are optimistic about the wind power resources in Kassala attracted more than a dozen enterprises to sign a wind power development agreement of 3 million KW, with a total investment of 0.5 billion USD.

The development of renewable power enterprises is also affected by whether they can master renewable power technologies, establish a technical foundation for the development and utilization of renewable power, and take the lead in the world. Overall, in some renewable power fields, Sudan is not backward in renewable power technology, except for its leading industrial scale in the world. In terms of solar energy utilization, the photoelectric conversion efficiency is about 10% for monocrystalline silicon chips, about 12% for polycrystalline silicon chips, and about 5% for thin-film cell amorphous silicon. The rated conversion efficiency of a Sudanese technology company's thin-film battery can reach 4%, which is high in the conversion efficiency of thin-film batteries. Sudan's hydrogen energy development is also developing rapidly. Since the late 1990s, hydrogen production technology has developed into a multi-channel technology including chemistry, biology, electrolysis, photolysis, and chemical heat treatment. Among them, fuel cell is an ideal hydrogen energy conversion device and a key technology for hydrogen energy utilization. In 2020, Sudan's annual output of hydrogen was close to threemillion tons, becoming the one of the small hydrogen producers in the world. In the process of realizing the greendevelopment, Sudan's hydrogen energy development technology can shorten the hydrogenation time of buses using hydrogen fuel cells from more than 10 hours to 15 minutes. This technology has played a key role in the transfer of automotive energy and market entry.

In addition to the market and technology, the cost is the key factor whether renewable power such as solar energy and wind energy can be used on a large scale and gradually replace traditional energy such as oil and coal. Reduce costs by innovating technology, expanding scale, and reducing raw material costs through intensive management, so that renewable power can be used on a market-based scale.

The excessive cost of solar power generation is due to the prohibitive cost of photovoltaic cells and low photoelectric conversion efficiency. Although the price of silicon materials has dropped due to the world fiscal crisis, the current cost is still threedollars per kilowatt hour. With the development of technology and the reduction of raw material prices, the cost of solar power generation is expected to be reduced again. The cost of solar power generation determines the degree of solar energy utilization. Measured in USD, if it can be reduced to 1 USD per kilowatt hour, it can be promoted in some economically developed countries and regions where energy is scarce. If it can be reduced to 0.5 dollars, it can be promoted in most countries and regions in the world with government subsidies and preferential policies. Japan plans to reduce the cost of photovoltaic power generation in the next 20 years, to 1.5 dollar per kilowatt hour in 2018, 0.93 dollar in 2020 and 0.47 dollar in 2030. The market prospect of photovoltaic power generation in Sudan lies in the cost level. In recent years, photovoltaic power generation is still dominated by silicon cells, but the cost of thin-film cells is lower and will develop rapidly, which is an optimistic trend. In addition, the government can also introduce preferential tariff policies to promote the development of solar photovoltaic power generation market. With the joint efforts of several parties, it is hoped that the electricity price will be reduced to less than 1 dollar per kilowatt hour. The United States has an elevated level of development. The national first solar company's solar photovoltaic power generation in the desert area of Nevada is 0.75 dollar per kilowatt hour, while the state's thermal power generation is 0.09 dollars per kilowatt hour, which has reached the level of parity on the Internet.

Compared with solar power generation, the cost of wind power generation is closer to that of thermal power. In 2020, the cost per kilowatt hour was 0.6dollar ~0.8 dollars, which is the lowest among renewable power costs. Considering the improvement of wind power technology and the reduction of the price of wind power equipment, the

cost of wind power can be further reduced. Another problem in the utilization of wind power in Sudan is that many wind farms are in remote areas in the west, and the transmission cost is high.

Technology, cost, and other conditions have different formation bases and development environments in different regions. Although the current level of renewable power utilization in many regions of Sudan is not high enough and the pace of development is not fast, this does not prevent regions from planning renewable power construction as a regional characteristic industry. In addition to the use of renewable power within the province, the equipment and facilities manufacturing industry can also be developed according to the regional industrial historical environment to form a renewable power industry manufacturing base with distinctive characteristics. For example, in addition to building wind turbine equipment manufacturing enterprises, it is also possible to build equipment components and parts manufacturing enterprises such as motor sets, wind turbine blades, towers, speed-up gear boxes, frequency converters, etc. to varying degrees. In this way, relevant equipment manufacturing enterprises, parts supporting enterprises, technology research and development and service institutions will be integrated into the industrial chain form to form a national basic framework for the renewable power industry. Of course, each component can be arranged in different areas. At present, whichever region has the conditions, advantages and initiative can take the first step and develop first.

IV. CONCLUDING REMARKS

The role of renewable power industry in promoting regional economic and social development is reflected in three aspects: first, investment pull. Accelerate the development of renewable power industry by attracting investment from central and local state-owned and private enterprises, create output value, promote employment, and increase taxes. Second, energy supply. Renewable power can provide alternative energy for the development of various industries, especially play a significant role in solving the problem of power consumption in remote areas and promoting rural electrification. It will be of positive significance in further improving the production and living conditions in rural and urban areas. Third, promote technological progress. The development of the renewable power industry and its chain can promote the attraction of talents, the establishment of research and development institutions, and the promotion of a series of related technological innovation and progress, which is conducive to the development of regional education and the promotion of social technological development potential. Of course, the national renewable power strategy should adapt to the local development mechanism. Local officials usually give priority to local issues, and local governments will choose their own interests in arranging the layout and pace of national energy development. Even though the central government emphasizes that local governments should take the overall situation into account, according to the regional standard psychology and the official performance driven mechanism, local government officials put the income, employment, safety, and health issues of the region in the first place. Therefore, we should coordinate the relationship between the central and local governments and promote the transfer of the focus of the national energy structure based on taking local interests into account. In short, the development of renewable power industry requires the joint efforts of four aspects, such as the enterprise power technology foundation cost level promotion mechanism, to form different regional characteristics to promote the strategic balance between regional development and the national energy industry.

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