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REVIEW ARTICLE

Thinking about the development of solar energy resources in Wulian County, Shandong Province

Zhichao Chen

Wulian Meteorological Bureau, Rizhao 262300, Shandong province, China. E-mail: czc0102@126.com.

ABSTRACT

In order to cope with the shortage of conventional energy and curb the sustainable development of global warming, it expounds on the natural conditions and national policies for the development of solar energy in Wulian County, and points out that the development and utilization of solar energy resources is an inevitable trend to cope with climate change, introduces the current situation of solar energy utilization in Wulian County, as well as the lack of specific policies and perfect economic subsidy measures, insufficient understanding of the strategic significance of solar energy resources, the fact that resource advantages have not been converted into economic advantages, and the prospects for solar energy utilization, such as solar water heaters. Solar ovens, solar cells, and solar power generation were analyzed, and the development and utilization of solar energy resources were promoted by formulating mandatory policies for the development and utilization of new energy, government incentive subsidies, and formulating development plans.

Keywords: Solar Energy; Current Situation; Prospects; Countermeasure Suggestions

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1. Introduction

As global temperatures continue to rise, weather conditions continue to deteriorate, and experts have predicted that "extreme weather may become the norm in the future". Compared to the past 500,000 years, the concentration of CO_2 in the atmosphere has exceeded the safe limit, and after the industrial age, its proportion has increased by 30%, mainly due to the combustion of fossil fuels. The average annual temperature of Wulian County from 2011 to 2015 has increased steadily, and there is a trend of increasing year by year compared with the average of the calendar year, of which the average temperature in 2014 is 14.2 °C, which is as high as 1.0 °C compared with the average of 13.2 °C in the calendar year, and the precipitation is unbalanced, the drought and flood are uneven, and the spring drought and autumn drought are serious. In 2016, the World Meteorological Organization proposed the theme of Meteorological Day, "Facing a Hotter, Drier, and More Waterlogged Future", and a slight increase in global average temperature may bring frequent climate disasters—excessive rainfall, widespread drought, and persistent high temperatures, resulting in large-scale disaster losses. Therefore, countermeasures should be taken to reduce greenhouse gas emissions and fully develop pollution-free energy[1]. The world is very rich in clean energy, as long as 0.5‰ can meet the needs of human beings. Solar energy is the largest, followed by wind and electricity, and there is also hydropower. The world develops new energy at an average annual growth rate of 12.4% every

year, and by 2050, the global new energy can reach more than 80% of the total energy, achieving a sustainable and clean energy supply and completely getting rid of the fossil energy dilemma. By then, global annual carbon emissions will return to 10.5 billion T, which is the level of the early 1990s, so the problem of controlling temperature rises at 2 °C or 1.5 °C can be solved, and China's smog problem can also be alleviated. Solar energy resources are abundant, can be used free of charge, without transportation, and have no pollution to the environment. The development and utilization of solar energy resources can not only solve the energy crisis, but also be a guarantee for coping with climate change, and the full use of solar energy will create a new model of life for mankind so that society and mankind can enter an era of energy conservation and emission reduction.

Since the 1970s, solar technology has advanced by leaps and bounds, and the use of solar energy has continued to evolve. In 2000, 70,000 households in Japan had installed solar power generation equipment, and in 2011, Texas, the United States, invented a new solar cell, which is only 2 US dollars per watt of power generation equipment. Domestic research on solar energy has also made great progress, Huang [2] pointed out that Shandong Province is relatively rich in solar energy resources, and solar water heater production in scale and competitiveness are at the forefront of the country's provinces and cities, but the photovoltaic industry is still in its infancy while analyzing the main problems in the development and utilization of solar energy in Shandong Province. Shen *et al*.[3-7] estimated the reserves of Solar Energy Resources in China, pointing out that China's solar energy resources have great potential, providing a way for various regions to develop and utilize solar energy. The author analyzes the development conditions, utilization status, and former[8-15] solar energy resources in Wulian County, Shandong Province, and puts forward countermeasures and suggestions for the development and utilization of solar energy in Wulian County, with a view to providing clean and safe modern new energy sources for residents' lives to cope with the climate crisis and alleviate the shortage of traditional energy.

2. Conditions for the development of solar energy resources in Wulian County

2.1 Natural conditions for the development of solar energy resources

Wulian County is located at 119.2 °E, 35.74 °N, located in the south of Shandong Peninsula, the northeast end of Rizhao City, east of Qingdao West Coast New Area, south of Rizhao City Donggang District, west of Ju County, north of Zhucheng, with a total area of 1,500 km², belonging to the warm temperate continental monsoon climate.

2.1.1 Characteristics of sunshine hours

The average annual sunshine hours in Wulian County are 2,393.5 h, and the number of sunshine hours in each month is the most in May and the least in December, and among the four seasons of the year, the spring season has the most sunshine hours, followed by summer, and the winter is the least. The annual percentage of sunshine is 54%, and the percentage of sunshine in each month is the largest in October, the lowest in July, and the average annual number of days with ≥ of 60% sunshine is 207.3 days.

2.1.2 Sunny days and cloud cover characteristics

The number of days on rainy days is low, with an average annual sunny day The number of days (average total cloud cover per day ≤20%) is 86.8 days, with the highest average number of sunny days in December at 12.8 days and the lowest number of sunny days in July. Wulian average annual total cloud cover is 55%, with the monthly average total cloud cover peaking in July and the least in December.

2.1.3 Characteristics of precipitation

In the same season as rain and heat, Wulian precipitation shows obvious seasonality, the degree of seasonal change is obvious, the average precipitation in summer is 489.7 mm, accounting for 62% of the whole year, and the average precipitation in winter is 36.8 mm, accounting for 5% of the whole year, and the rainfall is mostly concentrated in hot

season from June to August, and the precipitation in spring, autumn and winter is small, which is prone to drought.

2.1.4 Characteristics of foggy days

Since Wulian County is located in a hilly and mountainous area, the wind speed is large, the average number of fog days per year is 13.9 days, the maximum number of fog days in the year is 25 days, and the minimum number of fog days in the year is 4 days.

2.2 National and local policies for the development of solar energy resources

2.2.1 The State Council formulates new energy development prospects

In May 2015, the State Council issued the "Made in China 2025", which is the first ten-year action plan for China's implementation of the manufacturing power strategy, focusing on the development of a new generation of information technology, high-end CNC machine tools, and robots, aerospace equipment, energy-saving, and new energy vehicles, electric equipment, new materials, and other ten major areas.

2.2.2 National leaders point out the way to address climate change

On September 26, 2015, President Xi Jinping announced to the world at the United Nations Development Summit that "China's initiative to explore the construction of a global energy Internet and promote the clean and green way to meet global electricity demand" is a wise decision that depicts the prospects for the development of green and low-carbon energy for the world, points out a new way to deal with climate change, and demonstrates China's strength and Chinese style to the world.

2.2.3 The Energy Administration issued new energy guidance

On February 29, 2016, the National Energy Administration issued the Guiding Opinions of the National Energy Administration on Establishing a Guiding System for Renewable Energy Development and Utilization Targets. According to the current mining intensity, the world's coal can be mined for 110 years, natural gas can be extracted for 54 years, oil can be exploited for 53 years, facing the problem of depletion, solar energy resources are very important for promoting world peace and harmony and eliminating poverty. With the continuous innovation of making full use of solar energy technology, its economy will become more and more prominent, and its competitiveness will become stronger and stronger.

2.2.4 The national "13th Five-Year Plan" program actively supports solar power generation

In March 2016, China's "13th Five-Year Plan" was officially promulgated, and Chapter 30 of the Outline—Building a Modern Energy System", proposes to continue to promote the development of photovoltaic power generation, actively support solar thermal power generation, and put solar energy utilization in a very important position.

2.2.5 Wulian County government continues to promote photovoltaic power generation projects

In March 2016, Wulian County issued its 13th Five-Year Plan, which mentioned the implementation of six major environmental protection and energy-saving projects, of which the circular economy development project includes the exploration and development of photovoltaic power generation projects for large-scale factories in agriculture and enterprises in townships and towns of Zhongzhi, Wanghu, Street and Xumeng.

3. Overview of solar energy utilization in Wulian County

3.1 Solar energy to internal energy

3.1.1 Solar water heaters achieve large-scale popularization of Wulian from the 20th century

In the early 1990s, solar water heaters were vigorously promoted, from smoldering, collector pipe to vacuum tubes, and with the continuous development of new rural construction projects such as water supply villages and villages, the popularity of rural solar water heaters is also increasing year by year. Up to now, the urban solar water heater in Wulian County has been basically covered,

and the utilization rate of rural solar water heaters has reached more than 10%.

3.1.2 Passive solar greenhouses have been effectively promoted and applied

In the construction of the Central Primary School of Gongguan Town, Dujiagou Primary School, Wangjiazhuangzi Village Committee Office, etc. Solar greenhouses 2,880 m^2, the main structure is a vertical heat collection wall, heat collection wall. These include transparent materials, endothermic coatings, collector panels and insulation materials, roof ceiling panels with perlite and straw, and cinder on the ground.

3.1.3 Sun stove was further developed and utilized

Since 2002, Wulian County has taken the implementation of the project as an opportunity to introduce, develop and promote more than 4,000 solar stoves in street towns, which have been promoted to more than 6,000 households, and that has achieved great social benefits. At present, the solar cooker independently developed and developed by Wulian County has been exported to Qinghai, Tibet and other plateau areas.

3.1.4 The benefits of solar energy companies are prominent

The Wulian County produces solar water heater enterprises mainly have 2 homes, namely Rizhao Zhongke Meiyang Solar Manufacturing Co., Ltd. and Rizhao Leyu Solar Energy CO., Ltd. The annual output of the two companies reaches nearly 200,000 units, and the collector area exceeds 600,000 m^2.

3.2 Solar to electrical energy

Wulian Medium to Photovoltaic Power Generation Project is located in Wulian County, Rizhao City, Shandong Province, near Yaoyuzi and Shanghejiagou Village, covering an area of about 40 hm^2. Invested by Wulian Jingke Photovoltaic Power Generation Co., Ltd., the planned capacity is 20 MWp, which started in April 2016, went into production at the end of June 2016. A total of 1,331 solar street lights were installed on Fuqiang Road, Yantai Road, Changqing Road and other sections of Wulian County.

4. Problems in the development and utilization of solar energy resources

4.1 There are shortcomings in policy guarantees

Although a unified goal and program of struggle have been formulated and the Corresponding Wulian "13th Five-Year Plan" Circular Economy Development Project has been promulgated, specific support policies on how to achieve the ultimate goal have not yet been introduced, and the mandatory policies and regulations applicable to the region need to be refined as soon as possible.

4.2 Lack of understanding of the strategic significance of solar energy resources

The consumption of fossil energy in Wulian County is bound to cause energy and environmental pressure and increase greenhouse gas emissions. The development and utilization of solar energy are of epoch-making significance for rationally controlling the total amount of energy consumption, harnessing the ecological environment, and promoting sustainable economic and social development; large-scale solar power generation can adjust the power supply structure of Wulian County, which is mainly coal power generation, not to produce any degree of pollution, and to give people a hometown with blue skies and white clouds, green waters, and green mountains.

4.3 Lack of well-systematic economic subsidy measures

According to the actual situation of the development of the solar energy industry in Wulian County, there has been no relevant policy on whether to subsidize enterprises, purchasers, and solar products. Japan is already planning to introduce a series of preferential measures, and in 2016, the price of solar power generation systems will be reduced to 60,000 to 70,000 yuan. Foreign countries use economic leverage to promote the popularization of home solar systems. In Japan, households with solar power systems install two meters, one to record household consumption of the state grid' electricity, which is consumed by the household; the other calculates the amount of electricity transmit-

ted by the household power generation system to the national grid, which the government forces the grid to acquire. In Germany, the benign stimulus of the price difference is used to incentivize residents to use solar power generation systems, and the German electricity price alone is 0.1 EUR/kWh, while the price of the State Grid to acquire solar power generation is as high as 0.5 EUR/kWh.

4.4 Resource advantages are not translated into economic advantages

The transformation of solar energy resources into economic benefits is reflected by driving the development of industries related to the manufacture and processing of solar power generation products, and the second is the conversion of solar energy resources into electric energy, and the direct economic benefits are obtained through the sale of electric energy. Therefore, the transformation of solar energy resources into significant economic benefits requires the large-scale installation of solar power generation systems everywhere. Although Wulian County is rich in solar energy resources and has unique superiority, there is still a clear gap between the scientific research and utilization of solar energy resources and other areas with the same light energy conditions, and there is still a long way to fully transform the advantages of solar energy resources into economic advantages.

5. Prospects of solar energy utilization in Wulian County

5.1 Solar water heater

One of the most competitive ways of using energy economically and conventionally is that solar energy heats water from low to high temperatures to meet people's use of hot water in life and production. Solar water heater structure is simple, and low price, but also because domestic hot water is a perennial need, so solar water heaters can play a role throughout the year, there is a high utilization rate[16-18], and the current need to start to develop Wulian rural solar water heater applications. Liu *et al*.[19] conducted a study on the application status and prediction of solar water heaters in rural areas, and proposed that the premise of improving the utilization rate of solar water heaters in rural areas is to start from the regional economy, make farmers affluent as a whole, and add policies to benefit the people to promote the promotion of rural solar water heaters.

5.2 Construction of solar houses

The one-time investment in solar greenhouses is large, about 20% higher than that of ordinary houses, but the heating effect is quite impressive, which can bear 50% of the auxiliary heat source throughout the year, and generally recover the investment in the utilization of solar energy resources in 5 to 8 years. According to the test, when the outdoor is -1 °C, the indoors is maintained at about 15 °C; when the outdoors is above 30 °C in summer, the indoors can be maintained at about 18 °C. Compared with ordinary houses, solar greenhouses can save 22.60 kg/m^2 of coal for heating, and the energy-saving benefits are very significant. Liang *et al*.[20] have done research on the design and experiment of active solar houses, through the rational use of solar energy and surface water, it can effectively change the micro-environment in the room, save conventional energy, reduce environmental pollution, and achieve warm winter and cool summer.

5.3 Promote solar stoves

The solar stove is easy to operate, easy to use, clean and hygienic, and pollution-free, the service life is generally up to 15 years, longer than the service life of the liquefied gas stove. The use of solar-powered stoves not only improves the defects of cutting wood in rural areas and destroying the ecological environment, but also does not produce pollution, promotes environmental protection work, saves energy, and can return the cost within two years. Solar stoves that can be used for cooking throughout the day, in sunny weather, can ensure three meals a day, the temperature can reach 250 °C, can be used normally within 36 hours, can be steamed, boiled, fried, stewed, fried and other ways to cook. The scope of use of solar stoves is wide, as long as there is a sun, they can also be used in winter, and can be used for daily life, picnics, disaster prevention, and emergency occasions.

5.4 Solar greenhouses

The photovoltaic vegetable greenhouse is to install solar energy thin film panels on top of ordinary vegetable greenhouses, absorb solar energy, and divide solar radiation into light energy needed by plants and solar power generation, which not only ensures plant growth but also realizes photoelectric conversion. Photovoltaic vegetable greenhouses can not only generate electricity but also grow vegetables, one shed for dual use, increasing renewable energy, making agriculture move towards low-carbon, efficient, green, and circular agriculture. Shouguang City, Shandong Province, invested in solar photovoltaic vegetable greenhouses in 2014 and has been running well since the grid was connected, achieving gratifying economic and ecological benefits. The solar photovoltaic vegetable greenhouse is the product of the combination of solar photovoltaic energy technology and winter warm vegetable greenhouse, which can effectively use the existing vegetable greenhouse without occupying new land resources. Solar cell modules have a very high transmittance, greenhouse solar panels can be designed according to different areas of vegetable planting 97% or 75%, and other styles of light transmittance, in the power generation at the same time, can also meet the needs of plant photosynthesis on sunlight. Not only that, but solar cell components can also block some of the damage of ultraviolet rays to plants, which can effectively reduce vegetable diseases and insect pests and improve vegetable quality. In addition, the greenhouse photovoltaic system can also be matched with the LED system, and the night LED system can use the electricity generated during the day to provide lighting for plants, extend the irradiation time of vegetables, shorten the production cycle, and ensure the stable production of vegetables. At present, there are 53,000 hm^2 of vegetable greenhouses in Shouguang City, and if all solar photovoltaic vegetable greenhouses are built, they can generate 42.4 billion kW·h of electricity a year to meet the city's industrial and agricultural production and residents' daily electricity.

5.5 Launch of the sun roof program

After the installation of the household solar power generation system, on the one hand, the household electricity consumption system can be solved, on the one hand, the inexhaustible electricity can be sold to the state power grid, so as to activate the people's roof power generation and guide the generation of "zero energy construction" and "production capacity building" in Wulian. The Zhejiang government strongly supports the photovoltaic industry and plans to achieve 1 million rooftop power generation projects by 2020. In the first quarter of 2016, Jiaxing Xiuzhou Photovoltaic Town invested 562 million yuan in fixed assets ranked fifth in the second batch of 42 provincial-level characteristic towns. For one of the 10 provincial-level demonstration towns in Zhejiang, the "Jiaxing model" has been emulated by the whole country, and the essence of the "Jiaxing model" is to unify the roof development by playing the role of the government, and after power generation, in addition to the proceeds sold to the power grid, the state will receive an additional subsidy of 0.4 yuan/kW·h, Zhejiang subsidy 0.1 yuan/kW·h, basically, one year can recover the purchase cost of solar equipment.

5.6 Solar baking room

Tobacco production mode is changing from traditional labor-intensive to modern tobacco agriculture, especially tobacco roasting is transforming into a labor-saving, time-saving, and money-saving system. Because of the tax credit, the cost of building a solar oven in the United States is lower than that of a standard grill. In the bright and clean solar roasting room, the use of clean solar energy to replace coal-roasted tobacco leaves shortens the tobacco roasting time, the roasting efficiency can be increased by 29%, and zero emissions of tobacco roasting gas are realized. Wang *et al*.[21] conducted a study on the baking effect of the solar grilled tobacco in Guizhou, and the appearance quality and chemical composition of the flue-cured tobacco leaves were similar to those of the ordinary densely packed baking room, and the dry tobacco baking cost was 13% lower than that of the ordinary dense baking room. Solar roasting rooms can not only dry tobacco leaves but also other agricultural and sideline products and medicinal materials. Sav-

ing time and money with solar grilling houses, in winter, the electricity generated by the solar grilled roof power generation system is recycled by the National Grid.

5.7 Solar power generation

In recent years, the cost of thermal power has been rising day by day, and the development of the solar energy industry is just in time, and the rising "solar economy" will surely become the mainstream of global energy. For the development of the photovoltaic industry at this stage, Liang Zhipeng, deputy director of the New Energy Department of the National Energy Administration, said that if the photovoltaic industry wants to develop, it must be driven by innovation and upgraded. At the same time, reduce costs and reduce prices, so that large-scale applications can be realized. In order to promote technological progress and reduce prices, the State Energy Administration should expand the scale of the photovoltaic front-runner base and introduce a more perfect competition mechanism. Wulian's photovoltaic power generation industry started late, there are many difficulties and bottlenecks, the current solar photovoltaic utilization technology is still in its infancy, and subject to cost constraints, the effect is not ideal. However, with the advancement of scientific research projects and the research and development of new materials, the optoelectronic industry will gradually reach a mature stage of development[22-28].

5.8 Solar cells

China has successfully developed solar cells for rainy days, and on March 21, 2016, the research team of ocean university of China and Yunnan Normal University published a research report in the German journal "Applied Chemistry International Edition" to elaborate on this achievement, and the future development trend of solar cells may be all-weather. Solar cells can be used in illuminated lamps, electric vehicles, etc.[29]. The first choice is lighting, solar lamps have economic and environmental protection, energy saving, safety, long life, no need for wiring when installing, low operating costs, simple installation, and other characteristics, the more scale of the installation, compared to ordinary lamps and lanterns, the more saving investment. At present, electric vehicles are mainly based on the development of old scooters, and with the aging of the Population of Wulian, electric vehicles have great business opportunities.

6. Suggestions for the utilization of solar energy resources in Wulian County

6.1 Promulgate mandatory policies for the development and utilization of new energy sources

In hotels, hospitals, shopping malls, and other public places, it is mandatory to install solar energy power generation equipment[30] and make full use of solar power generation, so that it will have a certain peak regulation effect on the state grid; green quotas[31] are adopted, stipulating that power enterprises must produce a certain proportion of solar power, and the State Grid will buy back and implement more rewards and fewer penalties. Special funds for the development of solar energy resources must be put in place and law enforcement inspections must be carried out in depth.

6.2 Implement policies related to the promotion of solar energy development and utilization

Correctly interpret the special fund policy for energy conservation and actively implement it, and cooperate with the departments of the Development and Reform Commission to increase economic support for the promotion and application of the solar energy industry. Implement the state's tax reduction and reduction policy on new energy, and set up supporting encouragement awards.

6.3 Develop development plans

The competent department of solar energy will convene well-known domestic experts and local high-end skill-based professionals to draw a grand plan for the development of solar energy in Wulian County, plan a new pattern of solar energy development and utilization in Wulian County, and clearly put forward the strategic layout of solar energy development and utilization and short-, medium-term and long-term development plans.

6.4 Implement solar energy demonstration projects

Advocate the construction of a demonstration project for the integration of solar energy and buildings[32-35], actively guide and encourage solar water heater enterprises to participate in the construction of demonstration projects, and support the construction of integrated solar energy collectors systems for public buildings. Solar energy enterprise products in the street lamps, signal lights, and urban landscape lighting to expand the demonstration application.

6.5 Establish R&D institutions

The county government should attach great importance to technological development, introduce high-level technical personnel, improve the level of new energy research, encourage enterprises to participate in scientific research projects, and use scientific and technological innovation to promote industrial development and reduce costs. The solar energy industry is an emerging industry[36-38], with technological development by leaps and bounds, it is necessary to strengthen exchanges and cooperation with photovoltaic power generation research institutions and universities, follow up the latest trend of photovoltaic industry technology, combined with reality, according to the needs of industrial development to do a good job in the introduction of technology absorption, innovation. The government has given a certain degree of support in terms of funds and economic policies to promote the comprehensive strength of the development and utilization of Wulian Solar Energy.

6.6 Strengthen publicity and education

Give full play to the role of various news media platforms, publicize the great significance of solar energy development and utilization, promote and popularize the application of solar energy products in various fields, improve social recognition, and form a public opinion atmosphere conducive to the development of the solar energy industry[39-42]. To strengthen publicity and education aimed at government leaders at all levels and responsible persons of relevant departments, we should have a forward-looking awareness and establish a correct outlook on political achievements. The development of solar energy is in the contemporary era, the benefits are in the future, and the "sunshine economy" will be an inevitable choice for achieving economic development and protecting resources and the environment win-win situations and an inevitable trend of economic sustainable development.

Conflict of interest

The author declares no conflict of interest.

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