Study on the Application of Solar Energy Photo-voltaic Water Extraction Technology in the Typical Area of Guizhou Province

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Abstract. In this paper, the feasibility of the solar photo-voltaic water extraction technology in the typical area of Guizhou is studied and analyzed in this paper. Including the basic situation of the domestic and foreign research present situation, Guizhou solar energizes, solar energy in Guizhou comprehensive evaluation and utilization of the status quo, solar photo-voltaic provided water system composition, solar irrigation technology and traditional electric pumping technology contrast analysis (including economic cost, energy-saving emission reduction, technical advanced operation and other aspects of four). Finally, in Guizhou Province according to the actual situation of the proposed recommendations and conclusions.

Introduction

Solar energy and other new energy and renewable energy development and utilization is an important choice for Guizhou province to implement the strategy of the development of the western region, but also in line with the objective requirements of environmental legislation. The great development of the west is a major strategic decision made by the CPC Central Committee and the State Council. With the large-scale development of the western region of the large scale, the demand for energy is also growing, energy gap will be increasing, solar and other renewable energy resources development and utilization can not only alleviate the problem of energy shortage in Guizhou Province, but also from the source to improve the ecological environment, the western region's economic and social development and the "two rivers" area of the middle and lower reaches of the ecological security contribute. Solar water pump, also known as solar water pump. Today, it is considered the potential for the development of a new technology, and is especially suitable for light and heat conditions, the power shortage in remote rural areas. With a steady stream of solar energy to achieve high economic and reliability of water supply, solar energy can realize unmanned management according to the conditions of sunshine, automatic completion of water start and stop, with economy, reliability and environmental protection benefit is a kind of green energy high technology products.

Research Status At Home and Abroad

Photo-voltaic water pumping is a new technique developed rapidly in recent 30 years, the device core of photo-voltaic pump, optical electromechanical integration equipment, involving multiple disciplines electrical, mechanical, electrical and electronic, computer and control, the working principle for energy conversion process, through will be too Yang radiation energy conversion required for solar water pump power can, and then to drive the pump to carry water. Solar photo-voltaic water extraction system is mainly composed of 3 parts: solar energy storage battery, controller and solar water pump. Solar battery. The solar radiation energy conversion into electrical energy; controller mainly to invert the role, will be the realization of the direct current into alternating current, also on the pump frequency regulation and power compensation; solar water pump to give high priority to the use with wide high efficiency area of multistage centrifugal pump.
This kind of pump is equipped with special solar drive motor. In 1977, the United States put into operation 3 Solar pumping station, opened in the irrigation system in the use of solar technology. Europe and the United States, India, Brazil, Chile, Nigeria and other regions, have invested a lot of energy to carry out solar water extraction technology research. Among them: India plans on the basis of the existing 4000 units of photo-voltaic water pump, through government subsidies to promote the installation of 50 thousand units.

Solar photovoltaic water extraction technique involves light, machine, electricity integration, covering many cross subjects of advanced and new technology like solar energy’s collection and conversion, power electronics, motor, water machine and computer, thus many developed countries make it the priority to the development of high technology and the next step of development. The Middle East, Africa and other countries without water resources, is more vigorously to promote the technology combined with efficient water-saving irrigation technology, modern agricultural planting technology and other new technologies to its ecological environment for effective regulation and improvement.

At the end of last century, some domestic research institutes and researchers began to explore the technology of solar water extraction. At present, Jiangsu, Zhejiang, Guangdong walk in the forefront of the country. Combined with the Chinese Academy of machinery, Ministry of water resources, animal husbandry, Tsinghua University and other units of research results, Inner Mongolia, Qinghai, Xinjiang and other places have also been vigorously promoted it and achieved good results. In 2009, the Ministry of finance and the Ministry of housing issued Opinions on accelerating the implementation of the application of solar photovoltaic building and made subsidies for photovoltaic power generation, marking the use of solar energy in China phased into a new development period.

**Distribution Characteristics of Solar Radiation Resources**

Spatial distribution of annual solar radiation in Guizhou (Fig. 1). Appears in Zonal distribution. The highest value of years lies in the northwest of Guizhou Weining, up to 4697MJ/ square meters; lowest in eastern Guizhou Zunyi, 3340MJ/ square meters with the average for the 3888MJ/ square meters. The distribution of this radiation is closely related to the mountainous terrain of Guizhou and activities of the weather system in Southwest China. Guizhou’s radiation condition is mainly affected by the impact of the Yunnan Guizhou quasi stationary front.

Yunnan Guizhou quasi stationary front is south the cold air mass by the Yunnan Guizhou Plateau terrain blocking the formation of frontal is quasi south north, on average located near the 103. 5 degrees of 104 degrees e, vertical height of about 2000m, behind the front covered with large in low clouds, generally up to several hundred kilometers.

The spatial distribution of average annual sunshine hours in Guizhou is shown in Fig. 2, it is characterized by: the annual sunshine hours are between1735h/a and 1030h/a in Guizhou. The distribution of spatial is similar to the radiation, but the distribution of sunshine hours is relatively large, there is a low value center in the north central of Guizhou. This is because the terrain in Guizhou is complex, the elevation changes large, and the sunshine observation stations are over 80, more than radiation observation station; the distribution form of sunshine reflects change characteristics of terrain, elevation and weather system in Guizhou, provides good reference for city and county to carry out solar energy races.

**Distribution Characteristics of Total Cloud Cover**

Total cloud cover is a meteorological factor reflects the sky shaded degree of some region, it mainly affect the solar radiation and sunshine of the region. To make the calculation and analysis more convenient, the “number” show the cloud cover of some region is converged to percentage. For example, the observation value of cloud cover in sky is 7. 5, its substitution value is 75%, and so on. The distribution of total cloud cover in Guizhou is shown in Fig. 3, it is characterized by: the distribution of annual cloud cover in west was higher than east, and the highest was 84%, the lowest
was 74%. Its spatial distribution is consistent with Fig. 2, but the phase is just opposite. It could also be seen from Fig. 3: annual total cloud cover is 78% in the whole region in the west of 105° E, it is conducive to the development of solar energy utilization. But the total cloud cover was more than 80% in the region in the east of 26° N large, it has a negative impact on the use of solar energy.

Ambient temperature directly affects the utilization of solar collectors and solar hot water systems. The greater the temperature difference between ambient temperature and the average fluid of the collector, the lower the utilization rate of the solar energy. In addition, the ambient temperature also affects the solar energy and the solar energy utilization rate of the greenhouse. The distribution of annual average temperature in Guizhou is shown in Fig. 4. It can be seen, except for a small part of Northwestern region in Guizhiu, the annual average temperature was between 14°C and 19°C, so the temperature condition is good for the utilization of solar energy in most area of Guizhou. The south region in 26° N is pretty good.

![Figure 1. Distribution characteristics of annual total radiation in Guizhou(MJ/㎡).](image1)

![Figure 2. Distribution characteristics of sunshine duration in Guizhou(h/a).](image2)

**Present Situation of Solar Energy Development and Utilization in Guizhou**

The overall level of solar energy utilization is not high in Guizhou, many factors restrict the utilization of solar energy. In addition to lack of science and technology support and key technologies, policies and measures is not perfect, the management system is not smooth, and solar energy are also relatively insufficient, meanwhile, there is lack of scientific planning and fund. At present, the development of solar energy utilization is still in its infancy, solar thermal utilization is the main way, according to incomplete statistics, to 2008, total solar thermal utilization in Guizhou approximately amount to 10.627 million tons of standard coal, make the emissions of CO$_2$ reduced 22.60 million tons, SO$_2$ reduced 0.25 million tons, powder reduced 0.18 million tons.

Photovoltaic water pumping is a new technique developed rapidly in recent 30 years, the core of the device is photovoltaic pump, it’s an optical mechanical and electrical integration equipment, involving multiple disciplines: electrical, mechanical, electrical and electronic, computer and control, its working principle is to convert solar radiation energy into electrical energy, then drive the water pump by electric energy to achieve the effect of pumping. Solar photovoltaic water pumping system consists of photovoltaic cell, controller, photovoltaic water pump. Photovoltaic cell is a device to convert solar radiation energy into electrical energy. The controller is a device to convert DC power into AC power, achieve conversion control of the water pump frequency, and trace the maximum power point; photovoltaic water pump is a multistage centrifugal pump with wide high efficiency area, equipped with special solar energy to drive the motor.
Machine and Water Pump

All these measures of photo-voltaic pump system are to ensure stable and reliable water supply, at last, it will reflect on the operation of motor and water pump, they tend to form an assembly. The assembly require maximum reliability and efficiency. For photovoltaic water pump, collocation of motor and pump unlike the common situation, due to voltage level and power level of solar cell module control the motor’s in a large extent, so it should be specifically designed considering the solar energy cell component when the requirements of head and flow of water pump are reflected on the motor. For the different requirements of different users, there are kinds of drive motors used on the photovoltaic pump: different voltage levels traditional DC motor, brush-less DC permanent magnet motor, three-phase asynchronous motor, permanent magnet synchronous motor, reluctance motor, etc. From the current use, three-phase asynchronous motor and brush-less DC motor are the most, the large power system is still in the use of efficient three-phase asynchronous motor. In the motor design, the specific operating conditions of photovoltaic water pump should be fully taken into account, including: variable frequency operation, large load rate variety. In this case, diurnal and annual average efficiency of the motor should keep the highest, because it does not like an ordinary motor that can work in a constant voltage power supply.

According to the different requirements of users of the flow and head, the pump style can be chosen as follows: users require small flow, high lift can choose positive displacement pump; users require large flow and head should choose the submersible electric pump; users require large flow but low lift should choose self-suction pump motor and pump.

Maximum Power Point Tracking Device

It can be seen from I-V characteristic curve of photovoltaic array, location of output maximum power point is not fixed when the photovoltaic array are under different solar irradiation, and when the environment temperature changes, corresponding location of maximum power point will change. In order to achieve maximum power point tracking to get the most energy under current sunshine, MPPT is usually made in two forms as follows.

The maximum power point is located near the line: Umax=const, it will be nearer when the solar radiation is strong, at the same time, considering the following temperature characteristic of solar cell, when the temperature increase, in the same solar radiation open circuit voltage of UOC will decrease with the short-circuit current of Isc increase slightly. Considering the characteristics the higher the solar radiation, the higher the situation temperature, and the temperature characteristics of solar cell, they are both benefit to make the maximum power point trail approach the line: Umax=const in one day, in other words, the trail can be treated approximately as the line: Umax=const in engineering. Which constitute the theoretical basis of CVT.

Inverter

The output voltage is DC of photo-voltaic array through maximum power point tracker, if the pump driving motor is a DC motor, you can directly connect them when two voltage values matched, and the motor drives the rotary pump pumping, such as the early quiet products of Solarjack company in United States. The cost of DC motor is high, and it need regular maintenance or replacement of the brush. In recent years, due to the progress of new speed control theory and power electronic devices technology, AC speed regulation technology has great development, it has gradually catch up with the DC motor in efficiency, but its convenience and fastness is better than the DC motor, so the drive mode of brush DC motor will be gradually eliminated, high efficient three-phase asynchronous motor and DC brush-less motor will replace it, occasionally using permanent magnet synchronous motor or reluctance motor. The later several motor rely on a dedicated frequency conversion device or corresponding power electronic drive circuit to drive. Take three phase induction motor as an example to illustrate the basic principles of its drive.

AC drive is often divided into two major categories: square wave drive (including ladder wave
drive) and sine wave drive. Generally speaking, smaller power photo-voltaic water pump system (<300W) mainly take square wave drive, when the power is greater, for the limit of its harmonic losses, often take sine wave drive. Regardless of the drive, the basic circuit structure can be divided into the following four parts: ① switching power supply part; ② main circuit and drive circuit; ③ control circuit; ④ protection circuit.

Summary

(1) Pay close attention to the investigation of the solar energy resources in our province, to grasp the distribution of solar energies in various regions of our province, in order to determine the solar photovoltaic water extraction pilot area.

(2) Suggested in the period of development during the "12th Five Year Plan" period, focus on the research of solar irrigation technology system integration and the system construction, carried out a pilot demonstration, give priority to solving the welfare of poor areas of rural drinking water, dry hot valley area afforestation, desert, rock desertification problem. Secondly, it can be used in development, low water consumption and economic forest irrigation, industry market cultivation, accumulated experience of construction and development, form standardization, standardization of solar photovoltaic water construction and management rules, to provide support for the widely. "13th Five-Year" period, combined with small and medium-sized pumping station renovation, the promotion of solar irrigation technology.

(3) Due to solar photovoltaic provided water one-time investment larger, whether it is used for drinking or irrigation project, more than the state subsidies for the construction of standard, it is recommended at the provincial level for the solar photovoltaic provided the pilot water provide special funds to support.

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