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Design of Off-grid Home Photovoltaic Power System in Shaanxi Region

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ABSTRACT

Shaanxi province has three land forms which are Shaanxi's northern plateau, Guanzhong plain and Qinba mountain land in the south of Shaanxi province. So the climate type is also divided into three types and the solar energy resources distribution has a big gap between different regions. PV modules, as the core component of off-grid home photovoltaic power system, their output power are mainly influenced by sun radiation, array tile angle, temperature and so on. Based on the reasons above, in order to apply off-grid home photovoltaic power system in Shaanxi region, this paper designs different systems with different configuration, and makes the performance prediction. The results show that the capacity of PV modules reaches to the largest in Shaanxi northern region, reach minimum in Shaanxi southern region and the output power in the winter is less than in the summer and reach minimum in the spring and autumn. In light of the characteristics above, this research select different type and configuration in different areas systematically, and the performance analysis shows that the configuration can meet the basic life demand of power to the people whose power is not available.

Keywords: Solar; Photovoltaic Power Generation; Off-grid Home Photovoltaic Power System

1. Introduction

It is about 870 kilometers from Shaanxi northern to Shaanxi southern. Shaanxi province has three landforms which are Shaanxi northern plateau, Guanzhong plain and Qinba mountain land in south of Shaanxi. So climate type is also divided into three types. Shaanxi northern region belongs to warm temperate zone arid and semi-arid climate. Guanzhong belongs to warm temperate zone semi-humid climate and Shaanxi southern region belongs to north subtropical humid climate. In this case, the distribution of solar energy resource has a big gap in different regions, especially between north and south in Shaanxi province, the annual total sunshine radiation is 3830-5750 MJ/m^2, the annual sunshine hours is 1270-2900 hours and sunshine percentage is 28% - 64%.

Off-grid home photovoltaic power system mainly consists of PV modules, batteries, controller and inverter. Among them PV module is the core component that makes sun radiant energy into electricity. Power system's capacity is mainly influence by the sun radiation, array tile angle, temperature and other factors[1-2].

For example, the output power of crystalline silicon PV modules in proportion to the accepted sun radiation intensity, power generation efficiency is inversely proportional to the temperature. Based on the above reasons, in order to apply off-grid home photovoltaic power system in Shaanxi region, this paper designs different system with different configuration, and makes the performance prediction.

2. Resource Condition

In Shaanxi province the annual total solar radiation is in a high level, solar energy total reserve is 2.71 × 1015 kWh, ranking eleventh in China. The distribution characteristics are the radiation in the north is more than in the south. There is a great gap between north and south. High value areas are located in the Shaanxi northern along the Great Wall area and the east area of the north of Weishui, and low value areas are mainly distributed in Shaanxi southern[3].

According to annual total solar radiation, the solar energy resources of Shaanxi province can be divided into three areas: the area with very adequate solar resources, including Shaanxi northern; the area with adequate solar resources, including the south of Shaanxi northern, Guanzhong region, the northeast of Shangluo and Ankang in Shaanxi southern; the area with relatively adequate solar energy resources, including most areas of Hanzhong and Ankang in Shaanxi southern. Sunshine hours and sunshine percentage in Shaanxi are show in **Figures 1** and **2**.

In the four seasons, total radiation can reach maximum in the summer accounting for 35% of the annual total

radiation. In the summer around north of Shaanxi northern area and east area of northern Weishui the total solar radiation reach high value. In the winter total radiation reaches minimum and accounts for 16% of the annual total radiation.

3. Electricity Load

Reference to investigation in other areas, kerosene lamp, candles, fire and flashlight are the first choice to illuminate when photovoltaic power generation is not available, and TV, VCD, DVD and other appliances cannot use then. After photovoltaic power generation is available, lamp become the main lighting equipment, the use of household electric appliances, such as TV, tape recorder has a significant upward trend.

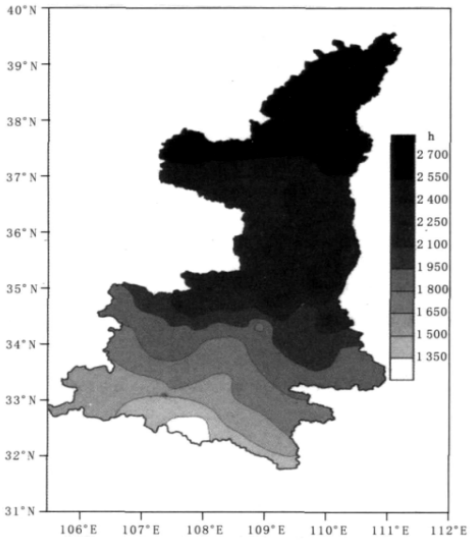

Figure 1. Sunshine hours in Shaanxi Province.

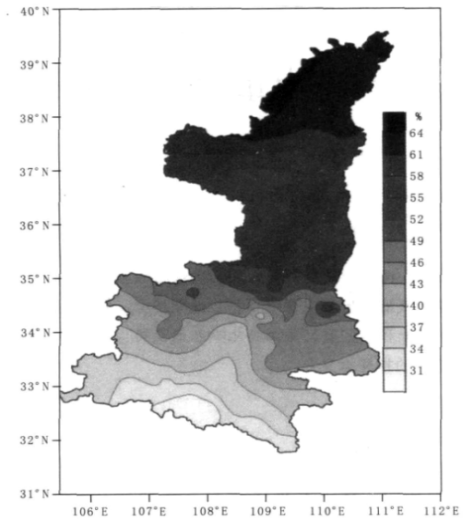

Figure 2. Sunshine percentage in Shaanxi Province.

Design load according to TV is 70 w, light is 30 w, the basic living power can be contented. Electricity time is 4 hours, power peak is around 100 W, average load is around 80 W.

4. Design Selection

4.1. Principle of Photovoltaic Power Generation

The solar cell of photovoltaic power generation is p-n junction which is surface contact type. When there is no light, it is equivalent to a diode. Otherwise the voltage between the two sides of solar cell gets just make p-n junction forward bias. The ideal equivalent power model is a constant current source in parallel a diode. The ideal I-V characteristic is:

$$I = I_L - I_0\left[\exp(\frac{qV}{nkT}) - 1\right] \quad (1)$$

I_L- photo current
I_0- saturation current of diode
q- charge quantity of electronic
k- Boltzmann constant
T- absolute temperature(K)

The output power is the product of current and voltage. It can be show use formula (2):

$$P = IV = I_L V - I_0 V\left[\exp(\frac{qV}{nkT}) - 1\right] \quad (12)$$

4.2. Design Calculation

It has shown the solar energy resources in eight cities of Shaanxi in **Figure 3**. In order to facilitate selection, placed 100 Wp monocrystal silicon components use local latitude as it's tilt angle and simulate to calculate the PV module's theoretical monthly output power, and the results show in **Figure 4**.

The results show that the output power in the winter is less than in the summer for the synthesis influence of local solar radiation and ambient temperature. Because the power generation efficiency of PV modules is inversely proportional to the temperature, when the temperature rise every 1℃, the efficiency drop about 0.5%.

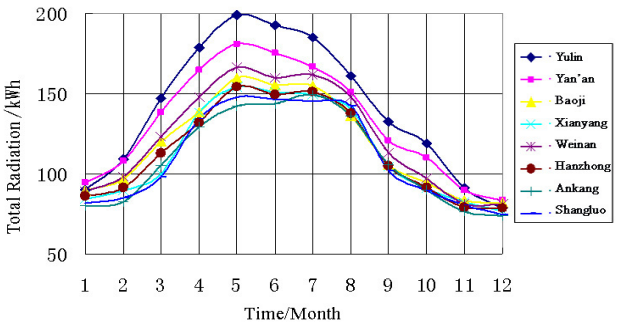

Figure 3. Global solar radiation in Shaanxi Province.

So in September and October, the output power reaches minimum generally. Especially in Yulin and Yanan although solar radiation is weak in the winter, output power is more than in the summer for the environment temperature is below zero.

4.3. Configuration Selection

According to the power load and PV module products series, the results are shown as in **Table 1**.

5. Performance Analysis

According to the configuration in **Table 1** and the local meteorological data, predict the output power of solar PV module in each area, which is shown in **Figure 5**.

It is assumed that the charging efficiency of battery is 90%, the working efficiency of inverter is 80%.The relationship between electricity generation and electricity consumption in every area is shown in **Figure 6**. The performance analysis results show output power of off-grid home photovoltaic power system is more than power consumption of TV and lamp. The configuration can meet the basic life demand of power to the people who power is not available.

6. Conclusions

The regional difference of solar energy resources distribution and temperature is big in Shaanxi as well as latitude difference. All of these are mainly influence factors of the performance of photovoltaic power generation system. Through the researches we can draw the conclusions:

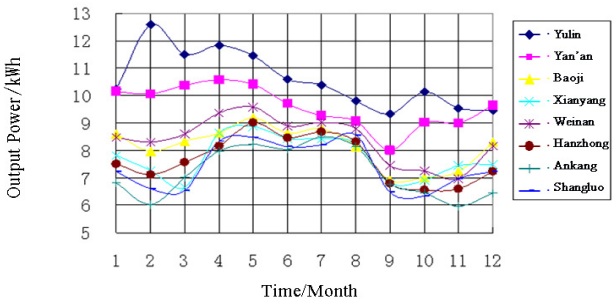

Figure 4. Output power of 100 Wp PV component.

Table 1. Type configuration.

No	Region	PV	Inverter	Battery
1	Yulin	135 Wp	300 VA	24 V65 Ah
2	Yan'an	170 Wp	300 VA	24 V65 Ah
3	Weinan	170 Wp	300 VA	24 V65 Ah
4	Baoji	180 Wp	300 VA	24 V65 Ah
5	Xianyang	180 Wp	300 VA	24 V65 Ah
6	Hanzhong	180 Wp	300 VA	24 V80 Ah
7	Shangluo	180 Wp	300 VA	24 V80 Ah
8	Ankang	180 Wp	300 VA	24 V80 Ah

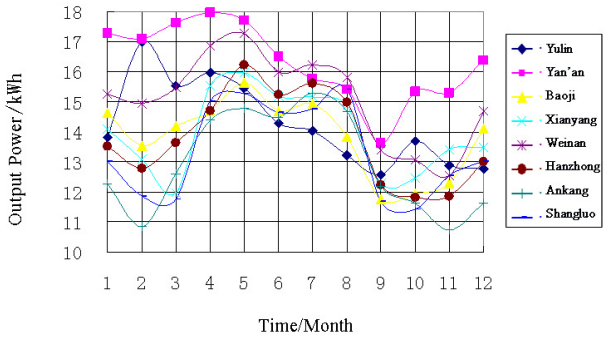

Figure 5. PV module output power prediction.

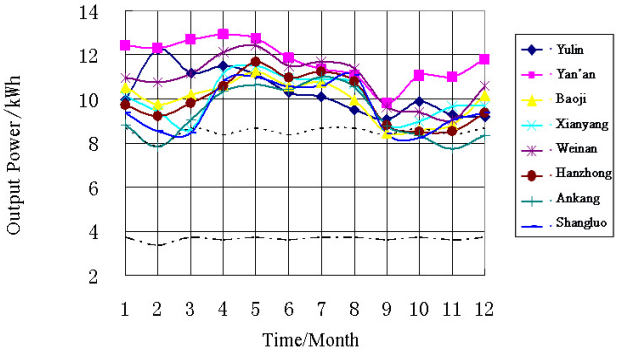

Figure 6. Output power prediction of off-grid home photovoltaic power system.

1) The output power of PV modules varies a lot in different areas of Shaanxi. It is mainly affected by the solar energy resources. The output power reaches to the largest in Shaanxi northern region, and the minimum occurs in Shaanxi southern region.

2) Because of the synthesis influence of solar resource and ambient temperature, output power in the winter is less than in the summer. It reaches the minimum in the spring and autumn.

3) According to the generating characteristics of PV modules in Shaanxi province, different types and configurations are selected in different areas systematically. The performance analysis shows that the configuration can meet the basic life demand of power to the people whose power is not available.

REFERENCES

[1] Divade, Z. R. Shi and H. Y. Lu, "The Pv-tech Application Study," Shanghai: Shanghai Jiaotong University Press, 2008.

[2] A. Li, "Solar Photovoltaic Systems Engineering," Beijing: Beijing Industrial University Press, 2001.

[3] L. R. Wu, Z. H. Jiang, Y. P. Lu, J. W. Du, L. Qiao and H. J. Liu, "Space Distribution Evolution Characteristics of Sunshine Duration and Percentage in Shaanxi Province," Xian: Shaanxi Meteorological. 2008.1.

