Feasibility Study and Electric Power Substitution Schedule for Photovoltaic Solar Greenhouse in Gansu

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Abstract. In order to overcome the constraints of natural environment for agricultural production, Gansu Province established the photovoltaic solar greenhouse project with the electric power substitution. This paper reviewed the development process of photovoltaic solar greenhouse over the years, and proposed typical substitute model of photovoltaic solar greenhouse combined with the actual situation in Gansu Province. This paper made comparative analysis of the cost between ordinary solar greenhouse and photovoltaic solar greenhouse, and evaluated the economy of photovoltaic solar greenhouse.

Introduction

As a new crop cultivation facilities, solar greenhouse can improve the efficiency of agricultural production. It ensures crop’s normal production activities through intelligent control, and the power consumption is essential in these processes, for example: exposing curtain in the morning, cover curtain at night, ventilation and lighting. A large area of greenhouses requires tremendous power; however, the traditional fuel of electricity generation is coal, which causes a series of environmental problems. Therefore, the use of solar photovoltaic power generation, can not only solve the lighting problems, but also provide a power guarantee for the entire greenhouse energy supply. This technology has been widely applied to many parts of the country. As shown in Fig. 1:

![Figure 1. Application examples of new photovoltaic solar greenhouse.](image-url)

To take full advantage of local solar and wind resources, Gansu Province has been developing solar greenhouse project for many years. October 2014, the "High-Altitude Intelligence Agricultural Demonstration Garden Project” co-operated by State Grid Energy Service Company in Gansu Province and China Agricultural University officially inaugurated in Lintao.
Photovoltaic Solar Greenhouse Substitution Schedules

According to the existing photovoltaic solar greenhouse cases, we design the photovoltaic solar greenhouse substitution schedules for Gansu Province, which is shown in Figure 2.

![Diagram of Photovoltaic Solar Greenhouse Substitution Schedules](image)

Figure 2. The photovoltaic solar greenhouse substitutive scheme in Gansu.

Overall, the establishment of photovoltaic solar greenhouse is to achieve the government-users-the grid company's linkage mechanism. Government provide capital subsidy to the photovoltaic solar greenhouse users. The user can achieve power self-occupied and the electricity surplus can be sold to the grid company. The grid companies should strengthen infrastructure construction to provide affordable electricity supply for users.

Feasibility Analysis of Photovoltaic Solar Greenhouse

According to survey data, this paper identifies the relevant parameters of ordinary solar greenhouse and photovoltaic solar greenhouse. The results are shown in Table 1.

<table>
<thead>
<tr>
<th>Project</th>
<th>Ordinary solar greenhouse</th>
<th>Photovoltaic solar greenhouse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction costs [Thousand yuan]</td>
<td>68</td>
<td>286</td>
</tr>
<tr>
<td>Life [Year]</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Power consumption [MWh]</td>
<td>85659</td>
<td>-15288</td>
</tr>
<tr>
<td>Price [Yuan/kWh]</td>
<td>0.44</td>
<td>1.2</td>
</tr>
<tr>
<td>Fixed costs [Thousand Yuan]</td>
<td>7.5</td>
<td>16.2</td>
</tr>
<tr>
<td>Total costs [Thousand Yuan]</td>
<td>16.6</td>
<td>12.2</td>
</tr>
</tbody>
</table>

Note: The calculation period is one-year, and the installed capacity of solar greenhouse is 20MW.

As can be seen from table 1, photovoltaic solar greenhouse costs is less than the total cost of ordinary solar greenhouse, additionally, photovoltaic solar greenhouse not only meet their own demand for electricity, but also can provide power to other users compared to ordinary sunlight.
greenhouse. Therefore the PV solar greenhouse has a good economy and can substitute the ordinary solar greenhouse.

Keeping other parameters constant, this paper changed the electricity sales price of agricultural production, price fluctuations impact to the cost difference between the two solar greenhouses is shown in Table 2 and Figure 3.

<table>
<thead>
<tr>
<th>Price Changes</th>
<th>-20%</th>
<th>-10%</th>
<th>0</th>
<th>10%</th>
<th>20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity sales price of agricultural production</td>
<td>0.352</td>
<td>0.396</td>
<td>0.44</td>
<td>0.484</td>
<td>0.528</td>
</tr>
<tr>
<td>The total cost difference</td>
<td>0.29</td>
<td>0.33</td>
<td>0.36</td>
<td>0.40</td>
<td>0.44</td>
</tr>
</tbody>
</table>

Figure 3. Price change effect for the cost difference between the two solar greenhouses.

As can be seen from Fig. 3, when the electricity sales price reached 0.0071 yuan /kWh, the cost difference between the two kinds of solar greenhouse is 0. When the price is higher than 0.0071 yuan /kWh, the total annual cost of photovoltaic solar greenhouse is lower than the ordinary solar greenhouse; and the difference between the two projects will increase with the growth of electricity price. Thus, 0.0071 yuan /kWh are the cut-off point of electricity price. Therefore, selecting the photovoltaic solar greenhouse is more economical when the price is higher than the cut-off point. The project is more economical, and the users’ design to select the photovoltaic solar greenhouse will be stronger.

Consider from the environmental benefits, the photovoltaic solar greenhouse is a new form of land utilization. It can not only achieve three-dimensional use of space, but also generate clean power. This way can expand the share of renewable energy supply, and promote photoelectric consumptive in Gansu, which bringing two-way benefit.

Therefore, in terms of electric power substitution and long-term goals of new energy generation, the wisdom agriculture represented by the photovoltaic solar greenhouse is the focus direction of the future reform in agricultural production.

Summary

(1) Photovoltaic solar greenhouse construction project in Gansu requires multi-party cooperation and participation of government, users and grid companies. Only in this way, we can realize the linkage mechanism of price - subsidies - affordable power supply.
(2) From the economic perspective, the cost of photovoltaic solar greenhouse is less than the ordinary solar greenhouse, which means the economy of photovoltaic solar greenhouse is feasible.

(3) The electricity sales price will affect the cost difference between the photovoltaic solar greenhouse and ordinary solar greenhouse; when the sales price is 0.0071 yuan / kWh, the cost of the two projects is equal.

References


