Research on Solar Photovoltaic Power Generation in the Airfield Area at Civil Airports

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Abstract: As a green and renewable energy source, the solar energy is advantageous due to its large reserve, economic performance, cleanness, and environmental protection, etc. Solar photovoltaic power generation in airports will produce excellent social, economic and environmental benefits with great significance in constructing green airports and promoting the energy conservation and emission reduction of civil aviation. This paper has analyzed the conditions necessary for solar photovoltaic power generation in the airfield area in civil airports in details, explored and studied the solar photovoltaic power generation in the airfield area in airports from multiple perspectives, and drawn relevant conclusions and suggestions.

1 INTRODUCTION

Along with the social development and scientific and technological progress, there is an increasingly growing demand for energy, coupled with aggravating energy crisis and environmental pollution day by day. Research and practice has shown that the solar energy is a renewable energy with the most abundant resources, wide distribution and is renewable without environmental pollution, which makes it the internationally recognized ideal alternative energy. Therefore, such clean, economic, safe and reliable renewable energy sources like solar energy have gradually become the foundation of future energy mix and been applied in production and living more and more widely. In the long-term energy strategy, the solar photovoltaic power generation will become the cornerstone for future energy source of human society and leading actor of the global energy landscape.

The aggregate of radiation resources of solar energy in China is relatively abundant. In regions covering over 2/3 of the total area of China, the annual sunshine duration exceeds 2,000 hours and the annual radiant quantity is more than 5,000 MJ/m^2. According to the statistics analysis, the total quantity of solar radiation exposure each year on the land area of China is 3.3×103～8.4×103 MJ/m^2, equivalent to 2.4×10.4 billion ton of the standard coal reserve. Therefore, the photovoltaic power generation technology has the biggest potential for renewable energy sources in China. Reasonable use of solar photovoltaic power generation can save resources, reduce pollution, and realize sustainable development.

2 CONDITIONS FOR SOLAR PHOTOVOLTAIC POWER GENERATION IN THE AIRFIELD AREA IN AIRPORTS

As the large energy consumers, besides ensuring the normal operation of flights, the civil aviation airports shall fully take advantage of large ground areas in airports to build the solar photovoltaic power stations on roofs of buildings in working areas and cargo transport areas as well as parking structures and open spaces around the airfield area, etc. and actively develop the renewable alternative energy sources, so as to meet the growing demand of civil aviation market. The airfield area of airports are suitable places for photovoltaic power generation. For one, this is because of no high-rise buildings around the airfield area of airports with little block, and for the other, there is sufficient venue for implementation of the photovoltaic power generation project. The airfield areas are relatively open and cover a large

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area with many unused spaces, such as green spaces and soil surface areas surrounding the runways. Without prejudice to the safety of flying and climbing and landing for planes, the airfield area can be used as one of the best sites for photovoltaic power generation.

According to the functions and features of the airport, photovoltaic power generation in the airfield area shall meet the following basic conditions:

- Solar energy resource in the airport area is relatively abundant with the ideal conditions for solar photovoltaic power generation.
- Wind power and wind direction in the airport area meet the requirements of photovoltaic power generation system. In case of areas with frequent heavy winds at disaster grade, it is unfit for constructing the photovoltaic power generation system.
- The site of solar photovoltaic power generation project shall be selected from the unused lands in the airfield area, such as soil surface area and green space around the runways by the side, meeting the requirements of safety and height in the areas relating to plane approach, transit, go-around, clearance, etc., and free from glare or electromagnetic interference.

3 ANALYSIS OF SOLAR PHOTOVOLTAIC POWER GENERATION IN THE AIRFIELD AREA

3.1 Analysis of Influence on Flight Safety

To install the solar photovoltaic modules near runways, it is required to consider airplane overrunning the runway by accident and bumping into the solar cell panels and it shall be ensured to minimize damages to airplanes.

By technical researches, the solar cell panel support can be manufactured as a mounting support that is easy to fold. Since the solar cell panel is brittle under impact, an additional infrared ray detection system for early warning can be installed. In the case that an airplane is about to crash to the solar cell panel or has crashed onto the solar cell panel system, the whole system could lie down to the ground instantly with its height lowered to a level below the height of the tires on the landing gear, so that the aircraft will be refrained from any damages and the occurrence of a disaster can be minimized. As for airplanes taking off or landing on other runways, since the airplanes are far enough in spacing and are not located right ahead of the pilot's compartment, and equipped with complete and mature navigation systems, the research indicates that the safe departure and landing by the pilot will not be affected even if the panels could reflect light.

The foldable photovoltaic support system is adopted, and the photovoltaic module shall be arranged and mounted vertically, and the detailed form of the foldable support is as follows:

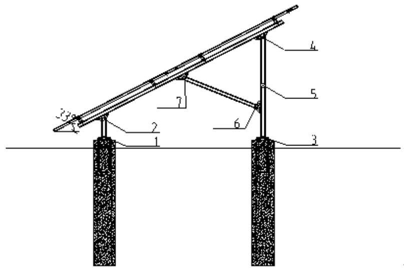

Figure 1: Drawing of the Photovoltaic Support

In Figure 1, the hinged joints 1, 2, 3, 4 and 6 are connected with bolts, which can rotate freely on the support plane; the hinged joint 7 is connected with a pull pin, which can also rotate freely on the support plane; the hinged joint 5 is fixed with rigid chain, which is in fixed condition under normal conditions, providing sufficient rigidity for the rear column. The pull pin of the hinged joint 7 and the rigid chain of the hinged joint 5 are connected with the motor. When an airplane overruns the runway by accident, touches the infrared ray surrounding the photovoltaic field and the motor is started, the pull pin of the hinged joint 7 is removed, making the hinged joint 5 rotate and the rear column lose rigidity, thus making the photovoltaic support been folded easily, so as to minimize damages to the airplane. Detail drawing of the folded support is as the following Figure2:

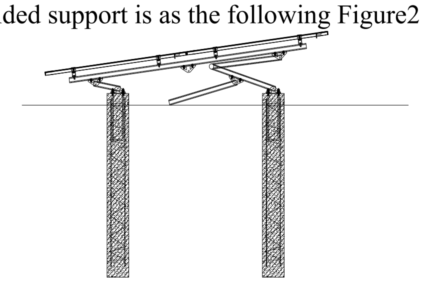

Figure 2: Drawing of Folded Support

3.2 Analysis of the Impact on the Air Traffic Control and the Navigation Station

As we all know, the frequency of direct current is equivalent to zero. Without alternating electric field and magnetic field, there is hardly any electromagnetic radiation in the direct current part. The electromagnetic radiation of a photovoltaic system is mainly concentrated at the part of equipment with alternating current. The photovoltaic module will not generate any electromagnetic radiation during power generation, however, in order to convert the direct current generated by the photovoltaic module into alternating current and connect to the power grid, many electrical equipment and electronic devices are generally needed, and such equipment and devices will have impact on the surrounding electromagnetic environment during operation. In the power field, the 50 Hz (or 60 Hz) frequencies are usually called the "power frequency" (the "PF"). The household electric appliances used in our daily life, such as, television, vacuum cleaner, fridge, electric blanket, electric razor and other appliances will generate power frequency electromagnetic field. With scientific measurement, the values in the electromagnetic environment of the solar photovoltaic power generation system are within the limited values of each indicator, and the values of the electromagnetic environment of the solar photovoltaic power station in the range of power frequency are even lower than values produced by common household appliances during normal operation, therefore, the system will have no electromagnetic interference with the navigation station as long as it is not located in the protective area of the navigation station.

The grid-connected inverter selected for the photovoltaic system in the Airfield area uses a metal case for shielding, therefore, the inverter will not produce excessive electromagnetic radiation beyond standard, and will have no impact on the airport navigation and flights. While the boosting transformer and other power switch cabinets and devices mainly generate power frequency radiation with relatively small amount of radiation energy, and they will have no impact on the airport navigation and flights, neither. Meanwhile, all distribution equipment can employ metal cases for shielding and grounding, so as to reduce electromagnetic radiation outward and reduce the impact on the system from external lightning. All cables outside of the earth surface use metal raceways or metal tubes for shielding protection, and the 10 KV cables are wired and connected with cable trenches under the earth surface. As a result, there are no circumstance that would affect the navigation station.

3.3 Analysis of Light Reflection

The light pollution of the photovoltaic power generation project mainly comes from the solar photovoltaic modules. Triple technologies can be adopted for solar cells to reduce the reflection of light, improve the utilization of optical energy and improve the conversion efficiency and quantity of power generation.

3.3.1 Anti-reflection Property of Crystalline Silicon Wafer

In order to improve the performance of solar cells, textured structure is usually manufactured on the surface of the silicon wafer. The effective textured structure causes the incident light to be repeatedly reflected and refracted on the surface, which can increase the absorptivity of light. Textured cells have a less reflection loss than glossy cells.

3.3.2 Anti-reflection Coating

When light hits the planar silicon wafer, a part of light is reflected; even when light hits the textured silicon surface, absorption increases due to multiple reflections of the incident light, but there still is about 11% reflection loss. A layer of anti-reflection coating on it can greatly reduce the light reflection. As anti-reflection coating is of good optical properties, and the refraction index is about 1.3 - 2.4, it can reduce the reflection of sunlight, and improve the absorptivity of light.

3.3.3 Anti-reflection Property of Special Glass Panel for Solar Energy

The main products of packaging glass for solar cells are low-iron tempered textured glass, which has a light transmittance of more than 91% in the wavelength range of the solar cell spectrum response (320-1,100 nm) and a high reflectivity of the infrared light greater than 1,200 nm. In order to improve the photoelectric conversion efficiency, glass cover with surface provided with a pyramid concave and convex design can be used. Such concave and convex pattern can inhibit the reflection of sunlight on the glass surface, so that more sunlight could reach the solar cells.

Compared with the natural surface reflectivity of common materials, the reflectivity of solar modules is lower, which is even less than the curtain wall of the outer wall of terminal. The impact on people in high-rise buildings or aircraft pilots is weaker than common situations on ground in the natural world.

3.4 Benefit Analysis

Solar energy is inexhaustible. Attributable to its nature of environmental protection, low carbon and emission reduction and zero consumption of energy resources, solar photovoltaic power generation is the new energy industry strongly supported and encouraged for development by the government. At present, subsidies are granted to distributed photovoltaic power generation projects in accordance with national policies, which will last 20 years. Relevant policies have also been promulgated by various localities to give financial subsidies to photovoltaic power generation projects.

According to the professional research data, each 1 kWh of electricity generated by photovoltaic power generation saves 0.4kgce and 4L of clean water, and reduces 0.272kg carbon dust, 0.997kg CO_2, 0.03kg SO_2 and 0.015kg NO_X at the same time. As it can be seen that social benefits, economic benefits and environmental benefits of the solar photovoltaic power generation project are remarkable.

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Through the analysis of impact on flight safety of solar photovoltaic power generation system, the analysis of impact on air traffic control and navigation station, the analysis of impact on light reflection, and the analysis of comprehensive benefits, it can be acknowledged that the construction of solar photovoltaic power station in the Airfield area will not affect the operational safety of aircrafts, and as long as appropriate safety assessments and demonstrations are made, PV modules can be installed in areas beyond taxiway and climbing and descending belt. From this perspective, solar energy utilization in airports has a very optimistic prospect as an important manifestation of the construction of green airports, which provides a new path for energy conservation and emission reduction for airports and even the civil aviation industry.

4.2 Recommendations

(1)After the completion of the airport photovoltaic power generation system, grid-connected power generation is required. The effective and reasonable grid integration of photovoltaic power generation system is a major issue to be solved in the power system of an airport, because the grid integration of photovoltaic power generation system involves the overall impact on the power grid of the whole airport. The airport power grid needs to carry out an optimized control for the grid-connected photovoltaic power generation system. Therefore, the grid integration of photovoltaic power generation must be addressed properly, power grid access shall be properly implemented, solar power grid integration shall be ensured, and the power generation and operation dispatch shall be rationally arranged, so as to improve the stability of grid-connected operation of photovoltaic power generation system, and enhance the power quality and the economy of entire power grid operation, making full use of solar energy resources in the airports.

(2) In consideration of the high initial investment in solar photovoltaic power generation, a large number of professional and technical personnel are required in the process of construction, operation and maintenance. It is suggested that the airport solar photovoltaic power generation project adopt the BOT mode (build-operate-transfer); the airport provides the site for the construction of photovoltaic power station and introduces social capital and specialized companies for investment, building and operation of the photovoltaic power generation projects. Professional companies and airport operation units shall sign relevant agreements, according to which fees shall be collected from users within the concession period as specified therein to recover the investment and make a profit. At last, the project shall be transferred to the airports in accordance with the agreements. The advantages of this model lie in reducing investment by the airport, avoiding a great deal of engineering risks, and being able to effectively utilize the advanced technology and management experiences of professional companies, which is beneficial to the smooth implementation of the entire photovoltaic power generation project.

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