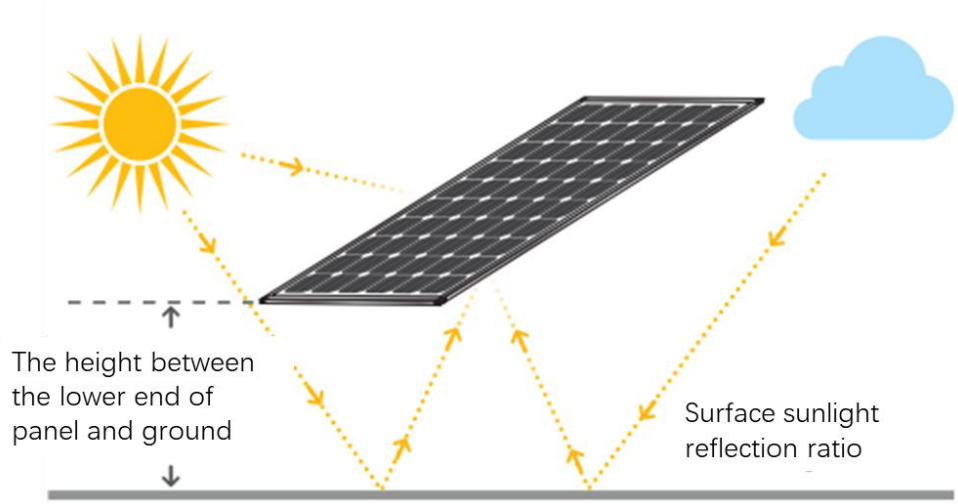
Test Report on Improving the Power Generation Efficiency of Bifacial Photovoltaic Panels by Using Solar Reflective Membrane at Huaneng Guanyun Thermal Power Plant

I. The Effect of Ground Solar Reflectivity on the Power Generation Efficiency of Bifacial Photovoltaic Panels

Bifacial photovoltaics are increasingly used in the market due to their better cost performance. It is expected to account for more than 70% of the market installed capacity by 2030. In addition to receiving sunlight on the front side to generate electricity, the back side of the photovoltaic panel receives sunlight reflected from the ground, resulting in additional power generation compared to single-panel panels.



According to multiple research data, under the same conditions, bifacial photovoltaic panels increase solar power generation by 15-30% compared to single-panel panels. The increase in power generation from bifacial panels mainly depends on two factors: the installation height of the photovoltaic panel and the ground's reflectivity to sunlight. Relevant reference data are as follows:

		SURFACE TYPE					
		concrete	green field	white gravel	sand	white roofing metal sheet	bright white roofing foil
		ALBEDO					
		16 % albedo	23 % albedo	27 % albedo	40 % albedo	56 % albedo	80 % albedo
INSTALLATION HEIGHT (m)	0.0	1.20 %	1.70 %	2.00 %	3.00 %	4.20 %	6.00 %
	0.1	2.30 %	3.30 %	3.90 %	5.80 %	8.10 %	11.60 %
	0.2	3.10 %	4.40 %	5.20 %	7.70 %	10.80 %	15.50 %
	0.3	3.60 %	5.20 %	6.10 %	9.10 %	12.80 %	18.20 %
	0.4	4.00 %	5.80 %	6.80 %	10.10 %	14.10 %	20.20 %
	0.5	4.30 %	6.20 %	7.30 %	10.80 %	15.10 %	21.50 %

From the above data analysis, it can be seen that increasing the ground's solar reflectivity will effectively improve the power generation efficiency of bifacial solar photovoltaic panels. When the ground's solar reflectivity increases to 80%, the power generation efficiency will increase by more than 20% at an installation height of 0.50 meters (distance from the lower end to the ground).

Methods to increase ground solar reflectivity include using white paint, high-reflectivity film materials, etc. Since it is used under outdoor environment, the material is required to have good corrosion resistance and weathering resistance properties.

II. Installation of High Solar Reflective Membrane on the Ground of the Bifacial Photovoltaic Panel Project at Guanyun Thermal Power Plant

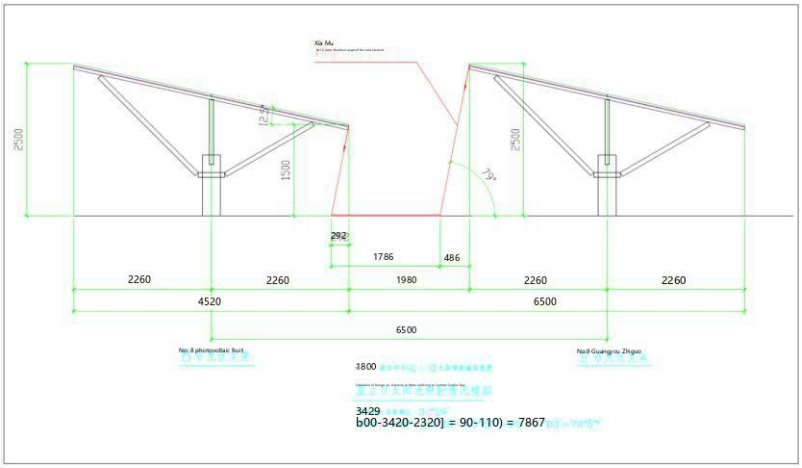
To further verify the impact of ground solar reflectivity on the power generation efficiency of bifacial photovoltaic panels and improve the power generation and economic benefits of existing solar photovoltaic projects, Huaneng Jiangsu Company's Guanyun Thermal Power Plant conducted a modification test on a bifacial photovoltaic power generation project located near the factory. The test project used ACC Weathering Membrane from San Miguel Yamamura Woven Products. This membrane material possesses excellent UV resistance and corrosion resistance, designed to withstand outdoor exposure for more than 20 years. It also boasts a solar reflectivity of up to 86% and having good hydrophobic properties, ensuring the surface is maintained with high reflectivity for a prolonged period. It is an ideal solar reflective membrane:

This project is located on the tidal flats surrounding its plant area; however, due to its location in the tidal flat region, the solar energy conversion efficiency of the photovoltaic panels on its back is not high.

Huaneng Thermal Power Plant selected a module (using the same inverter) in its photovoltaic area for relevant testing, covering an area of approximately 2000 square meters. Installation of this project commenced on July 10, 2024, and was completed on August 7, 2024.

After comprehensive field investigations and analysis of the angle and lighting conditions from summer solstice to winter solstice, as well as considering the high amount of dust near the project site and the need for maintenance access, a reflective membrane layout plan was developed. A total of 1.8-meter-wide and 6-meter-long reflective membrane support was made.

135 pieces are installed on the ground below each group of photovoltaic brackets, arranged in 3 rows in a continuous manner. The analysis method and the layout method of the reflective membrane brackets are used as shown in the diagram below: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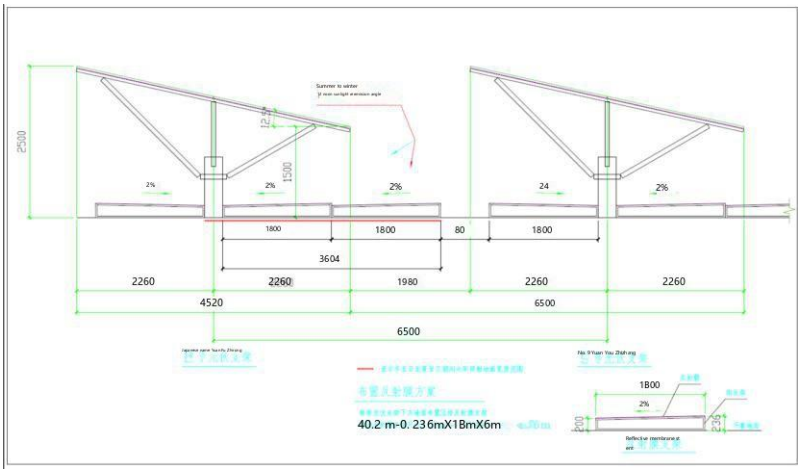
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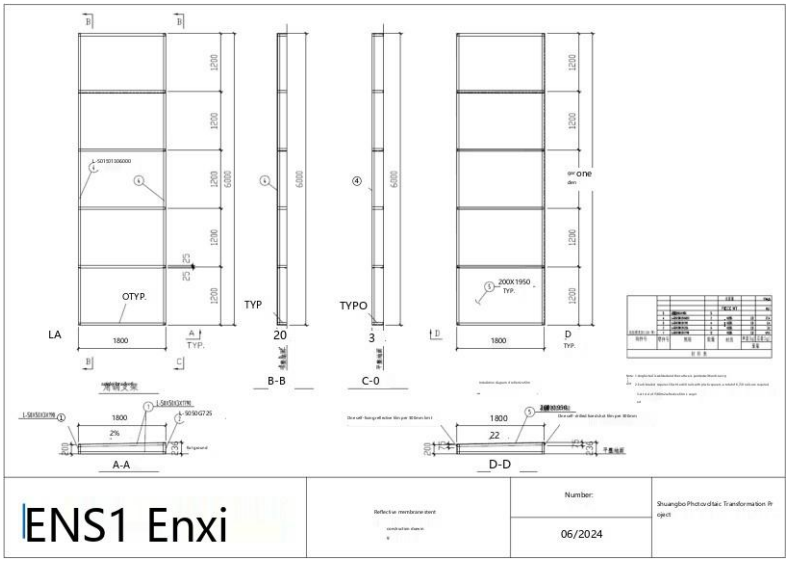
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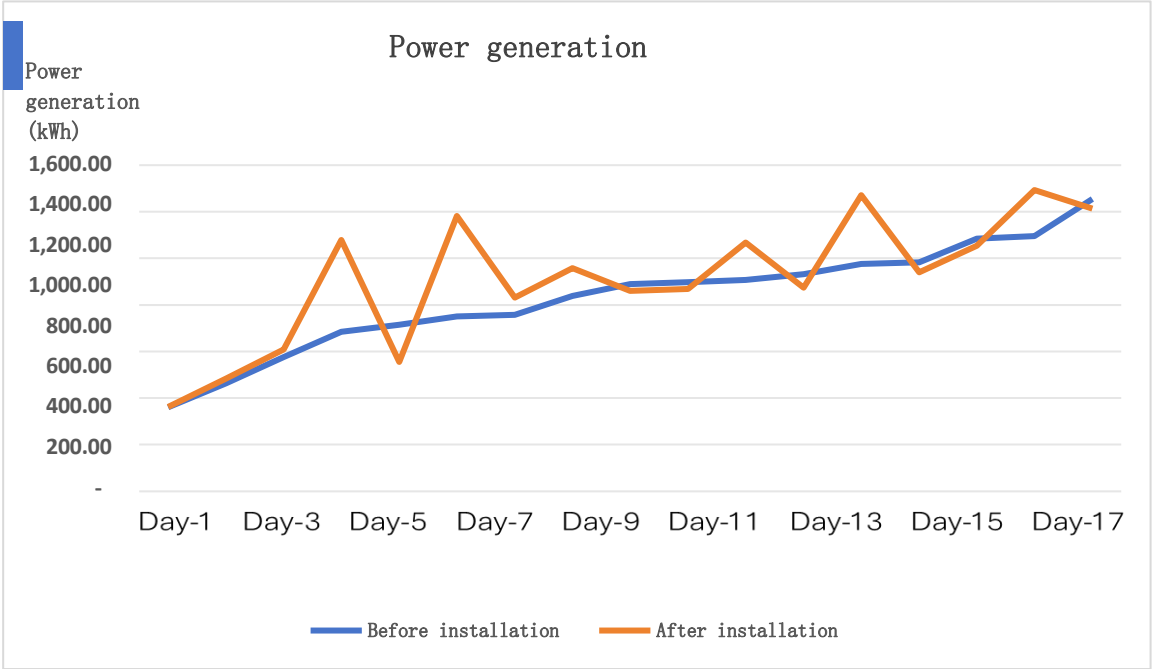
On-site installation

III. Power Generation Analysis Before and After Reflective Membrane Installation

After installation, we compared and analyzed the data before and after the module installation. We selected power generation data with equivalent cumulative irradiance over 17 days before and after installation. The comparison data is as follows:

Number of days	Irradiance kwh/m²	Date (before installation)	Power generation (kWh)		Irradiance kwh/m²	Date (after installation)	Power generation (kWh)
1	1343	7.20	381.71		1268	8.20	377.38
2	1851	7.19	500.44		1807	8.8	517.78
3	2532	7.27	629.90		2440	8.21	661.49
4	5220	8.20	755.08		5440	8.11	1,203.64
5	2680	7.18	790.38		2615	8.14	600.67
6	5961	8.30	830.68		5598	8.23	1,322.77
7	6266	7.29	840.10		6246	8.12	919.19
8	5022	8.10	932.93		5436	8.90	1,063.65
9	4998	7.2	990.94		5189	8.2	951.23
10	4497	7.2	1,001.13		4975	8.19	960.99
11	4351	7.26	1,011.39		3725	8.18	1,191.43
12	4823	7.25	1,040.88		5167	8.24	967.22
13	5452	7.2	1,090.54		5566	8.16	1,425.12
14	6068	7.28	1,099.36		5759	8.13	1,044.16
15	5325	7.22	1,216.24		5456	8.10	1,174.67
16	6227	7.30	1,229.38		6189	8.17	1,450.94
17	6177	7.31	1,412.69		5923	8.22	1,359.26
	78793		15,753.77		78799		17,191.59
						Increase	9.13%



Based on the above data, under the same cumulative irradiance, the power generation before installation of ACC reflective membrane was 15753.77 kWh, and the power generation after the installation was 17191.59 kWh. Compared with before installation, the overall power generation growth rate was 9.13%, achieving a better expected effect.