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Demonstration Monthly Report
光伏组件户外实证（宁夏）- 月度报告
PV Module Outdoor Field Test (Ningxia)- Monthly Report
No. TRPVP02038/22P/01

Client: 安徽大恒能源科技有限公司 **Anhui Daheng Energy Technology**
客户 **Co., LTD**

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申请人: Applicant	安徽大恒能源科技有限公司 Anhui Daheng Energy Technology Co., LTD
申请编号: Applicant Number	PVP02038/22P
评估日期: Date of Evaluation	2022 年 04 月 01 日—2022 年 04 月 30 日 April 1 st , 2022 to April 30 th , 2022
评估标准: Standards of Evaluation	IEC 62446 Grid connected photovoltaic systems – Minimum requirements for system documentation, commissioning and inspection IEC61724-1: 2017 Photovoltaic system performance – Part 1: Monitoring IEC61724-3:2016 Photovoltaic system performance –Energy evaluation method IEC 60904-1:2006 Photovoltaic devices - Part 1: Measurement of photovoltaic current-voltage characteristics. IEC 60904-3:2008 Photovoltaic devices - Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data. IEC 60904-9:2007 Photovoltaic devices - Part 9: Solar simulator performance requirements. IEC 61215:2005 Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval.

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1 实证项目概况

本项目装机容量为 1808.84 W, 共四块两个版型组件固定倾角安装, 采用微型逆变器一拖二形式并网。两个版型的组件都是 182 PERC 单晶单面组件, 其中一个版型组件的电池为 1/3 切片, 电池片数量 6*30, 正面无边框全面屏设计。另一个版型组件的电池为 1/3 切片, 电池片数量 6*30, 普通边框设计。实证的目的在于对比户外自然积灰和雨水清洗的情况下, 两个版型组件的发电量差异。

项目地址位于宁夏银川市西夏区光伏实证基地, 其试验场地面主要为自然地面(土石杂草)。于 2021 年 12 月获得国建能源局批复, 2022 年 2 月开工建设, 2022 年 3 月竣工验收完成, 光伏并网电网升压等级为 10 kV。

1 Demonstration Project Overview

The PV power station has a power generation capacity of 1808.84 W. This project contained 2 different types of PV modules at a fixed installation angle and applied tow-in-one grid-connected micro-inverters. These 2 types of PV modules are 182 PERC mono-crystal PV modules. One of the types is one-third cut with 6X30 pieces of cell and has no frame on the front A-side. The other type of PV module is the regular one-third cut with 6X30 pieces of the cell. The purpose of this test is to compare the differences in power generation between 2 types of PV modules, under the natural outdoor dust sedimentation and rain wash conditions.

This project is located in the PV Field Test Base in Xixia District, Yinchuan City, Ningxia Province. The outdoor test environment is nature ground (with soil, rocks, sand, and grass). Approved by the National Construction and Energy Administration in December 2021, construction started in February 2022 and finished in March 2022. The photovoltaic grid-connected grid boost level is 10kV.

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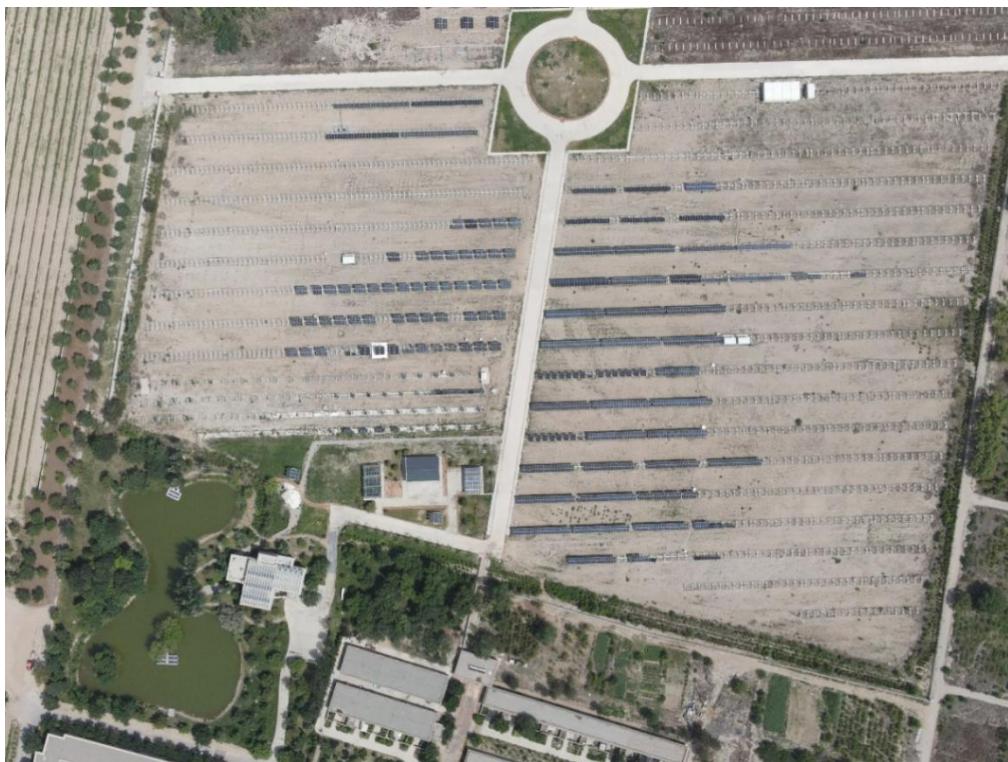


图 1 宁夏实证基地全景图

Picture 1 Ningxia Field Test Base Panorama

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图 2 项目实景图

Picture 2 Project Image



图 3 组件积灰局部图

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Picture 3 PV Module Sand Sedimentation Image

项目基本信息如下：

项目容量: Project Power Generation Capacity	1808.84 W
项目地点: Project Location	中国宁夏回族自治区银川测试基地 PV Field Test Base in Xixia District, Yinchuan City, Ningxia Province
GPS 坐标: GPS Coordinates	38°36'56.77"N, 106°0'52.27"E
年辐照小时数: Annual Sun Exposure Hours	1971
年平均温度: Annual Average Temperature	8.9 °C
并网日期: Date of Grid Connection	2022 年 3 月 March 2022
组件倾角: Installation Angles	5 °

设备基本信息如下：Equipment Information

序号	品名	标称功率 (W)	型号	数量	备件数量
1	全面屏组件 The Full-Screen PV Module	460	DHT-M60X10/FS -460W	2	1
2	普通组件 The Regular Module	460	DHT-M60X10 -460W	2	1
3	微型逆变器 Micro-inverter	1500	HM-1500 (2 路独立 MPPT) (2 independent MPPT)	2	-

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传感器基本信息如下: Sensor Information

序号	设备名称	型号	安装区域	数量	备注
1	六要素气象站 Six Elements Weather Station	MULTI-6P	中心气象区 Center Weather Zone	1	风速风向温度 湿度雨量气压 Wind Speed Wind Direction Temperature Humidity Rainfall Pressure
2	辐照度计 Radiometer	Kipp&zone CMP11	Center Weather Zone	2	GHI、DHI
3	辐照度计 Radiometer	Kipp&zone CMP10	Center Weather Zone	7	7个角度 7 Angles
4	直射辐照度计 Direct Radiometer	Kipp&zone CHP1	Center Weather Zone	1	-
5	辐照度计 Radiometer	Kipp&zone SMP10 辐照计 radiometer	阵列平面 Plane Array	1	根据组件需求 配置 Configure according to PV module requirements
6	温度传感器 Temperature Sensor	STM-4	实证区 Demonstration Zone	若干 Several	根据组件需求 配置 Configure according to PV module requirements
7	辐照度信号 采集模块 Irradiance Signal Acquisition Module	CPVT_M_m	实证区 Demonstration Zone	若干 Several	-

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8	温度信号采集模块 Temperature Acquisition Module	CPVT_M_T	实证区 Demonstration Zone	若干 Several	-
9	组件传感器 PV Module Sensor	PVMS	实证区 Demonstration Zone	若干 Several	每组件 1 套 1 Sensor per group
10	数据采集器 Data Collector	M.A.P MINI	实证区 Demonstration Zone	1	-

组件曝晒 60kWh/m^2 后安装于支架上进行户外实证发电量测试, 曝晒后电参如下: After PV modules exposure under the sunlight 60Wh/m^2 , installed on the frame and implement the outdoor power generation field test. The results are listed below:

版型	序列号	Isc	Uoc	Im	Um	Pm	FF
DHT-M60X10/FS -460W	185821061000100058	9.08	61.80	8.67	52.15	452.27	80.63
	8012201B1004122128	9.13	61.95	8.69	52.49	456.31	80.66
DHT-M60X10 -460W	8012110D0504143514	9.02	61.85	8.62	52.47	452.15	81.01
	8012110B0703212360	9.03	61.64	8.61	52.04	448.11	80.55

2 项目运行情况 2 PROJECT OPERATION

2.1 太阳能资源 2.1 SOLAR ENERGY RESOURCES

项目的组件安装倾角为 5°，本月其正面辐照量为 170.28 kWh/m²，平均环境温度为 17.20 °C，平均风速为 2.36 m/s。

This project installation angle is 5°. The Front irradiance is 170.28 kWh/m² in April. The average temperature is 17.20°C and the average wind speed is 2.36 m/s

以下是每日气象数据统计： Daily Weather Data Statistics

日期 Date	日累计正面辐照 Daily Cumulative Front Irradiance (kWh/m ²)	日平均环境温度 Average Daily Temperature (°C)	日平均风速 Average Daily Wind Speed (m/s)
2022/4/1	6.74	13.74	4.01
2022/4/2	6.97	11.82	2.05
2022/4/3	6.90	15.35	1.76
2022/4/4	4.82	16.94	2.30
2022/4/5	7.04	19.49	2.02
2022/4/6	7.15	20.39	2.78
2022/4/7	7.17	21.54	2.12
2022/4/8	4.68	22.27	2.53
2022/4/9	6.32	25.39	2.73
2022/4/10	6.38	25.77	2.16
2022/4/11	3.46	14.53	3.45
2022/4/12	5.53	13.27	2.36

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2022/4/13	3.10	10.42	1.97
2022/4/14	4.14	12.27	1.77
2022/4/15	1.83	10.13	2.17
2022/4/16	5.47	12.09	2.11
2022/4/17	5.02	11.32	3.25
2022/4/18	7.31	15.07	2.11
2022/4/19	7.07	17.26	2.42
2022/4/20	6.81	21.09	2.21
2022/4/21	5.26	20.42	3.20
2022/4/22	7.03	20.52	2.07
2022/4/23	6.19	23.81	1.87
2022/4/24	7.13	25.41	2.19
2022/4/25	5.38	24.42	2.11
2022/4/26	6.48	15.33	3.25
2022/4/27	2.36	12.74	2.08
2022/4/28	7.21	15.92	1.78
2022/4/29	2.04	13.84	1.94
2022/4/30	7.31	13.50	2.05

2.2 发电量情况 2.2 POWER GENERATION

本月实证基地总发电量为 138.27 kWh，自监控以来累计发电 138.27 kWh，等效满负荷利用为 152.88 小时 (kWh/kW)，自监控以来累计 152.88 小时 (kWh/kW)。在计算发电量增益时，以 DHT-M60X10-460W 组件为 Baseline。

In April, the total power generation in the Field Test Base is 138.27kWh. The PV power station has cumulatively generated power of 138.27 kWh since monitoring. The equivalent full load utilization is 152.88 hours (kWh/kW), and 152.88 hours have been accumulating since monitoring (kWh/kW). When calculating the power generation increase, used PV modules with model type: DHT-M60X10-460W as Baseline.

各类型组件所在组串，本季发电量情况对比如下：All types of PV modules generate power, after series connected in this season:

型号 Model	实验室 功率 (W) Lab Power	当月 发电量 (kWh) Monthly Power Generation	当月 等效 小时数 Monthly Cumulative Power Generation per Watt	当月 发电量 增益 Monthly Power Generation Increase	累计 发电量 (kWh) Total Power Generation	累积 等效 小时数 Total Cumulative Power Generation per Watt	累计 发电量 增益 Total Power Generation Increase
DHT-M60X10/FS-460W	454.29	73.21	161.17	11.50%	73.21	161.17	11.50%
DHT-M60X10-460W	450.13	65.06	144.54	-	65.06	144.54	-

2.3 弃光及数据异常情况 2.3 Abandoned Light and Abnormal Data

项目本月未出现弃光，自并网以来累计无弃光。

No abandoned light was found in this month and hasn't found abandoned light since the project connected to grid.

本次报告数据覆盖日期为 4 月 1 日至 4 月 30 日，期间未出现数据中断。

This report data uninterruptedly collected from April 1st to April 30th.

检查实时采集的正面辐照、环境温度、风速和组件输出电压、电流和功率等数据，未发现数据异常，数据质量较高。检查 MAP 系统采集的组件夜间温度和白天温度数据，DHT-M60X10/FS-460W 版型序列号为 185821061000100058 组件的温度传感器发现异常，反馈银川基地的运维人员，确认是温度传感器的胶带脱落导致的异常，已采用耐高温高黏性的胶带重新固定粘贴；DHT-M60X10-460W 版型两块组件的温度传感器未发现异常。本月度数据分析，剔除异常温度传感器的数据，以保证更高的数据分析准确性。

Check the real-time collected data such as Front Irradiation, Temperature, Wind Speed, and PV Module Output Voltage, Current, and Power. No data anomalies are found, and the data quality is high. Check the nighttime and daytime temperature data of the PV modules collected by the MAP system. The temperature sensor of the DHT-M60X10/FS-460W version with the serial number of 185821061000100058 is found to be abnormal. After reported the abnormal to the operational and maintenance staffs of the Yinchuan base, confirming that the abnormality is caused by the tape of the temperature sensor falling off, and it has been fixed with high-temperature-resistant and high-viscosity tape. The temperature sensors of DHT-M60X10-460W was found normal. The abnormal temperature sensor data was eliminated to ensure the accuracy of the monthly data analysis.

3 监测指标明细 3 Details of Monitoring Indicators

3.1 组件温度特性分析 3.1 Module Temperature Characteristic Analysis

依据本月各组件监测的温度、功率数据，可以记录到每种组件工作状态下，各温度区间的功率响应特性。

According to the temperature and power data monitored by each PV module in April, the power response characteristics of each temperature range can be recorded under the working state of each PV module.

温度: $\leq 0^{\circ}\text{C}$

Temperature: $\leq 0^{\circ}\text{C}$

型号 Model	最小功率 (W) Minimum Power	最大功率 (W) Maximum Power	平均功率 (W) Average Power	单瓦性能 Performance per Watt
DHT-M60X10/FS-4 60W	-	-	-	-
DHT-M60X10-460 W	-	-	-	-

温度: $0\sim 10^{\circ}\text{C}$

Temperature: $0\sim 10^{\circ}\text{C}$

型号 Model	最小功率 (W) Minimum Power	最大功率 (W) Maximum Power	平均功率 (W) Average Power	单瓦性能 Performance per Watt
DHT-M60X10/FS-4 60W	19.77	131.01	51.38	11.31%
DHT-M60X10-460 W	17.55	114.95	45.99	10.22%

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温度: 10~20°C

Temperature: 10~20°C

型号 Model	最小功率 (W) Minimum Power	最大功率 (W) Maximum Power	平均功率 (W) Average Power	单瓦性能 Performance per Watt
DHT-M60X10/FS-4 60W	8.04	509.59	96.30	21.20%
DHT-M60X10-460 W	7.53	464.42	89.26	19.83%

温度: 20~30°C

Temperature: 20~30°C

型号 Model	最小功率 (W) Minimum Power	最大功率 (W) Maximum Power	平均功率 (W) Average Power	单瓦性能 Performance per Watt
DHT-M60X10/FS-4 60W	7.08	515.13	196.20	43.19%
DHT-M60X10-460 W	6.50	467.52	177.07	39.34%

温度: 30~40°C

Temperature: 30~40°C

型号 Model	最小功率 (W) Minimum Power	最大功率 (W) Maximum Power	平均功率 (W) Average Power	单瓦性能 Performance per Watt
DHT-M60X10/FS-4 60W	59.17	468.32	315.01	69.34%
DHT-M60X10-460 W	53.14	425.14	284.63	63.23%

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温度: > 40°C

Temperature: > 40°C

型号 Model	最小功率 (W) Minimum Power	最大功率 (W) Maximum Power	平均功率 (W) Average Power	单瓦性能 Performance per Watt
DHT-M60X10/FS-4 60W	100.23	456.63	365.34	80.42%
DHT-M60X10-460 W	90.88	416.27	325.22	72.25%

3.2 组件强弱光响应特性分析 3.2 Analysis of PV Module Strong and Weak Light Response Characteristics

依据本月各组件监测的辐照、功率数据，可以记录到每种组件工作状态下，各辐照区间的功率响应特性。

According to the Irradiation and Power Data monitoring, the power response characteristics of each irradiation range can be recorded under the working state of each PV module.

辐照: ≤200 W/m²

Irradiation: ≤200 W/m²

型号 Model	最小功率 (W) Minimum	最大功率 (W) Maximum	平均功率 (W) Average Power	单瓦性能 Performance
DHT-M60X10/FS-4 60W	7.08	93.35	54.43	11.98%
DHT-M60X10-460 W	6.50	82.20	48.57	10.79%

辐照: 200~400 W/m²

Irradiation: 200~400 W/m²

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型号 Model	最小功率 (W) Minimum	最大功率 (W) Maximum	平均功率 (W) Average Power	单瓦性能 Performance
DHT-M60X10/FS-4 60W	79.61	191.25	128.09	28.20%
DHT-M60X10-460 W	70.99	165.74	113.22	25.15%

辐照: 400~600 W/m²

Irradiation: 400~600 W/m²

型号 Model	最小功率 (W) Minimum	最大功率 (W) Maximum	平均功率 (W) Average Power	单瓦性能 Performance
DHT-M60X10/FS-4 60W	161.28	279.87	220.80	48.60%
DHT-M60X10-460 W	146.17	249.32	194.70	43.25%

辐照: 600~800 W/m²

Irradiation: 600~800 W/m²

型号 Model	最小功率 (W) Minimum	最大功率 (W) Maximum	平均功率 (W) Average Power	单瓦性能 Performance
DHT-M60X10/FS-4 60W	241.00	363.35	304.54	67.04%
DHT-M60X10-460 W	218.12	327.57	269.91	59.96%

辐照: 800~1000 W/m²

Irradiation: 800~1000 W/m²

型号 Model	最小功率 (W) Minimum Power	最大功率 (W) Maximum Power	平均功率 (W) Average Power	单瓦性能 Performance per Watt
DHT-M60X10/FS-4 60W	323.09	451.27	382.65	84.23%

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DHT-M60X10-460 W	291.62	409.52	341.00	75.76%
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辐照: > 1000 W/m²Irradiation: > 1000 W/m²

型号 Model	最小功率 (W) Minimum	最大功率 (W) Maximum	平均功率 (W) Average Power	单瓦性能 Performance
DHT-M60X10/FS-4 60W	399.32	515.13	434.12	95.56%
DHT-M60X10-460 W	363.87	467.52	397.41	88.29%

3.3 发电能力分析 3.3 Analysis of Power Generation Capacity

依据测算得到的组件日累计发电量，以及组件的初始实验室测试功率，可对每种版型的组件在当月运行的日累计 kWh/kW 发电量进行计算比对。测试结果如下表。

Based on the calculated daily cumulative power generation of the PV modules and the initial laboratory test power of the PV modules, the daily cumulative kWh/kW power generation of each type of the PV modules in April can be calculated and compared as follows:

日期 Date	DHT-M60X10/FS-460W	DHT-M60X10-460W	增益 Increasing
2022/4/1	6.55	5.75	13.91%
2022/4/2	6.70	5.87	14.14%
2022/4/3	6.61	5.79	14.16%
2022/4/4	4.59	4.03	13.90%
2022/4/5	6.70	5.86	14.33%
2022/4/6	6.87	6.01	14.31%
2022/4/7	6.79	5.94	14.31%
2022/4/8	4.48	3.94	13.71%
2022/4/9	6.04	5.31	13.75%
2022/4/10	6.04	5.29	14.18%
2022/4/11	3.31	2.91	13.75%
2022/4/12	5.35	4.68	14.32%
2022/4/13	2.97	2.62	13.36%
2022/4/14	3.96	3.48	13.79%
2022/4/15	1.67	1.49	12.08%

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2022/4/16	5.10	4.68	8.97%
2022/4/17	4.79	4.39	9.11%
2022/4/18	6.89	6.29	9.54%
2022/4/19	6.65	6.08	9.38%
2022/4/20	6.39	5.85	9.23%
2022/4/21	5.02	4.58	9.61%
2022/4/22	6.53	5.97	9.38%
2022/4/23	5.80	5.30	9.43%
2022/4/24	6.61	6.06	9.08%
2022/4/25	4.95	4.54	9.03%
2022/4/26	6.14	5.60	9.64%
2022/4/27	2.14	1.97	8.63%
2022/4/28	6.68	6.07	10.05%
2022/4/29	1.85	1.69	9.47%
2022/4/30	7.00	6.50	7.69%

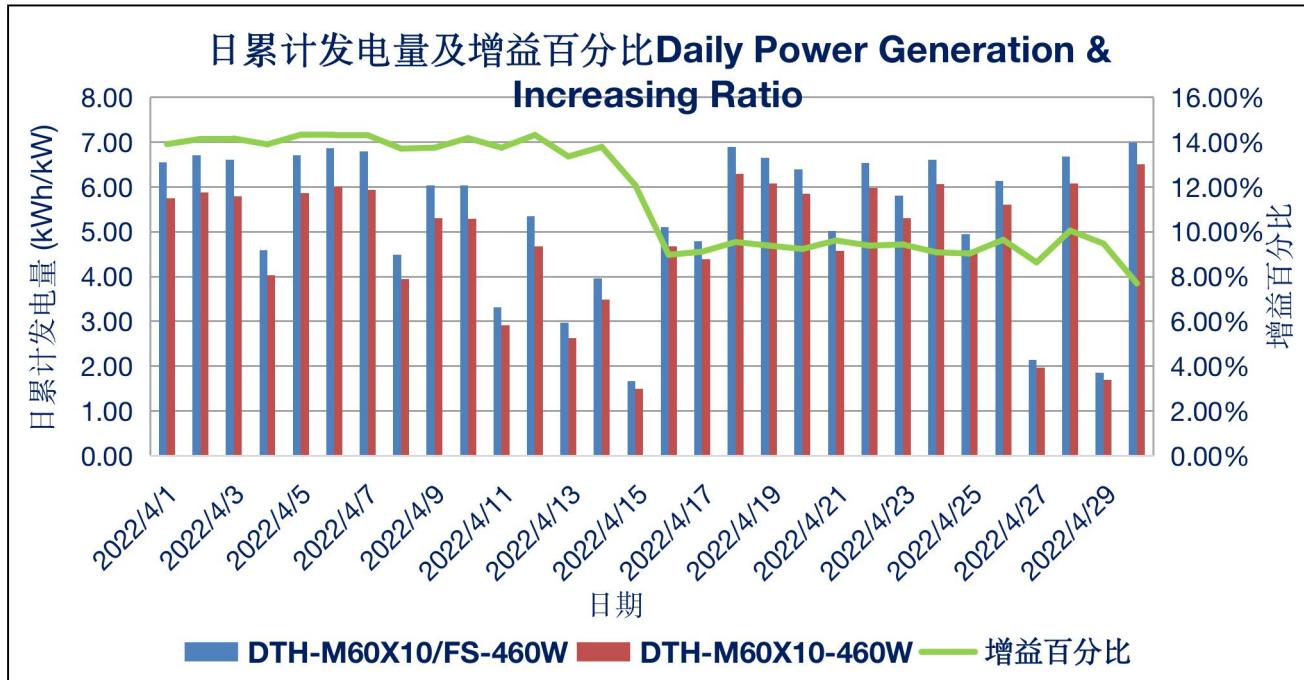


图 4 日累计发电量及增益百分比

Picture 4 Daily Power Generation & Increasing Ratio

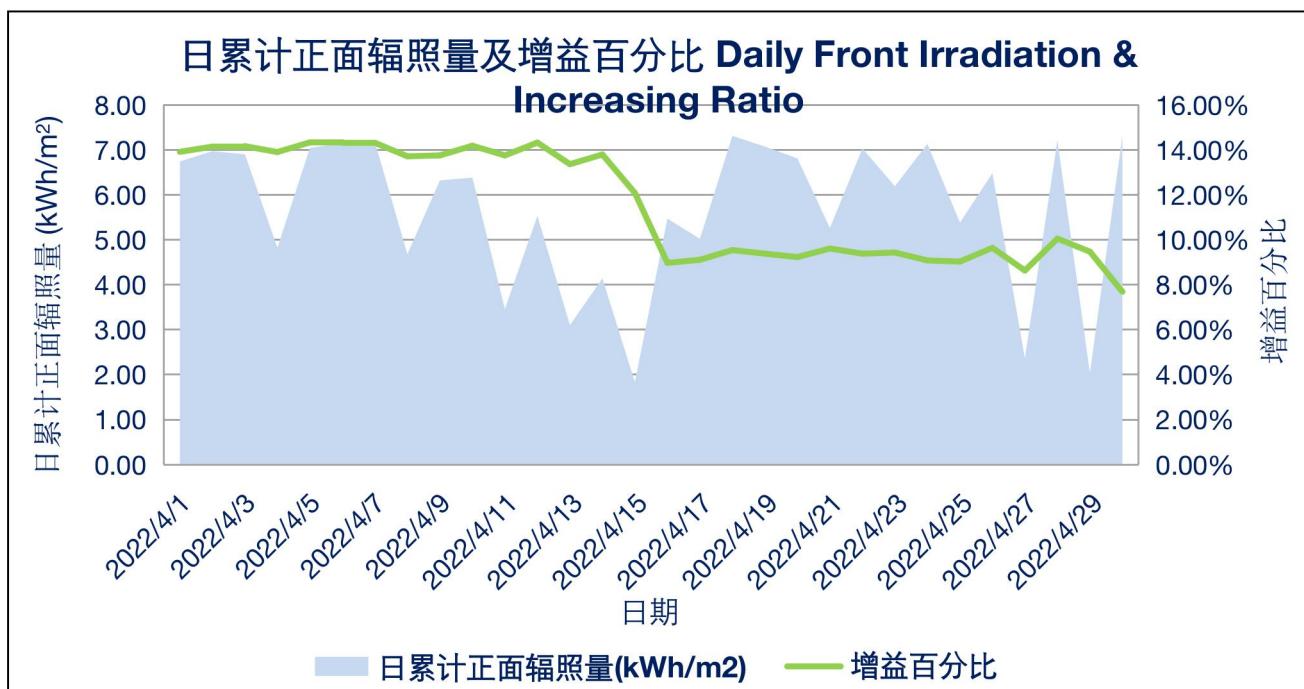


图 5 日累计正面辐照量及增益百分比

Picture 5 Daily Front Irradiation & Increasing Ratio

3.4 系统效率 3.4 PV Module System Efficiency

3.4.1 测试介绍 3.4.1 Test Introduction

为了测试电站已经并网部分的整体系统效率, 在评估期间使用高精度的气象数据采集装置连续采集电站太阳辐照量数据, 对电站的发电效率进行核算分析。本项目电站 PR 核算所用到的实际发电量数据将通过电站的数据采集器 M.A.P MINI 和组件传感器 PVMS 获取。

In order to test the efficiency of the entire PV power station, the high-precision meteorological data acquisition device continuously collects the solar radiation data of the power station and analyze the power generation efficiency of the PV power station. The power generation data used in the PR accounting of the power station of this project obtained via the data collector M.A.P MINI of the power station and the PV module sensor PVMS.

参照 IEC 61724-3 标准, 本项目选用能量效率作为评估标准, 计算公式如下表:

Referring to the IEC 61724-3 standard, this project selects energy efficiency as the evaluation standard, and the calculation formula is as follows:

$$PR = \frac{E_{out}}{E_T} \times 100\%$$

E_{out} : 光伏系统实际发电量, 单位: kW•h; 数据以天为单位统计; Actual power generation of the photovoltaic system, Unit: kW · h; Daily collected

E_T : 光伏系统理论发电量, 单位: kW•h; 数据以天为单位统计; Theoretical power generation of photovoltaic system, Unit: kW · h; Daily collected

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$E_T = P_0 \times (H_i / G_{i,ref})$ -----理论发电量计算公式; Theoretical power generation calculation

formula

P_0 : 光伏电站装机容量, 单位: kWp; (峰值功率) 以实际并网容量统计; PV power station Installation capacity, Unit: kWp; (peak power) calculated according to the actual grid-connected capacity

H_i : 阵列面接收到的辐射量, 单位: kWh/m²; 数据以天为单位统计; The amount of radiation received by the plane array, Unit: kWh/m²; Daily collected

$G_{i,ref}$: 标准测试条件的辐照度 Irradiation at Standard Test Conditions, 1000W/m²;

3.4.2 测试结果 3.4.2 Test Results

组件型号 PV Module Model	装机容量 Installation Capacity (W)	理论发电量 Theoretical Power Generation (kWh)	实际发电量 Actual Power Generation (kWh)	系统效率 PV Module System Efficiency
DHT-M60X10/FS-460W	454.29	77.36	73.21	94.64%
DHT-M60X10-460W	450.13	76.65	65.06	84.88%

3.5 分组能力对比 3.5 Grouping Capacity Comparison

对比参数包括组件系统效率和等效小时数 (kWh/kW) 两个指标。

2 Indicators of the comparison parameters: PV Module System Efficiency and Cumulative Power Generation per Watt (kWh/kW).

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组件型号 PV Module Model	等效小时数 Cumulative Power Generation per Watt	系统效率 PV Module System Efficiency
DHT-M60X10/FS-460W	161.17	94.64%
DHT-M60X10-460W	144.54	84.88%

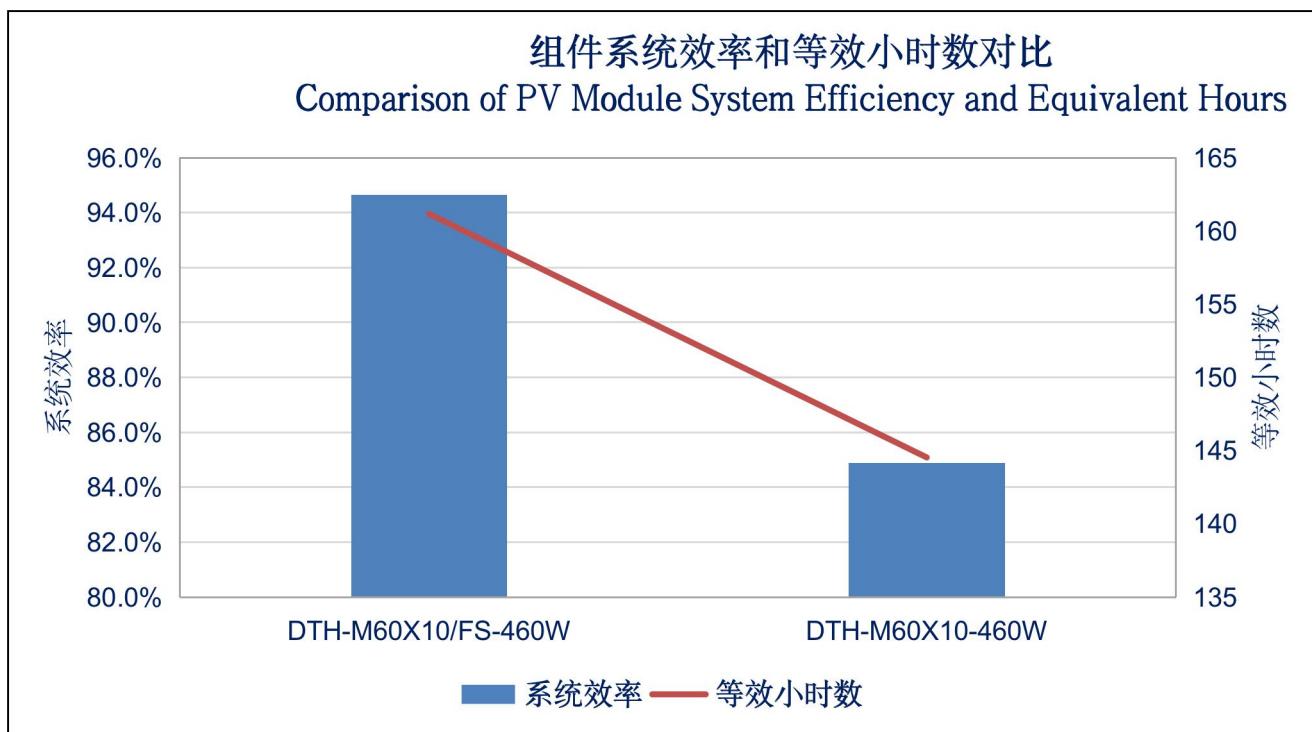


图 6 组件系统效率和等效小时数对比

Picture 6 Comparison of PV Module System Efficiency and Cumulative Power Generation per Watt

4 总体评价 4 Overall Evaluation

本月宁夏基地监测的大恒能源全面屏组件 (DHT-M60X10/FS-460W) 发电量为 73.21 kWh, 等效小时数为 161.17 kWh/kW, 系统效率为 94.64%; 常规组件 (DHT-M60X10-460W) 发电量为 65.06 kWh, 等效小时数为 144.54 kWh/kW, 系统效率为 84.88%。目前尚未发现明显低效组件，各项运行指标均满足实证要求。

In April, the TÜV Experimental Base in Ningxia finished the field test on the Full-Screen PV Module, which was innovated by DAH Solar. The test result demonstrated the Full-Screen PV Module, DHT-M60X10/FS-460W, generated 73.21kWh, and the cumulative power generation per watt is 161.17 Kwh/kW. The solar system efficiency is 94.64%. In the contrast, the regular PV module, DHT-M60X10-460W, generated 65.06kWh, and the cumulative power generation per watt is 144.54kWh/kW. The solar system efficiency is 84.88%. At present, there is no low efficient PV module is found. All the operational standards have met the demands.

屋顶小倾角光伏组件因受雨水冲刷作用而形成的底部积灰带, 是屋顶分布式光伏电站局部阴影遮挡损失、热斑效应等危害的主要原因, 表面均匀积灰是次要原因。这层积灰带成为宽窄厚度不一的遮光带, 甚至形成完全阴影遮挡, 严重降低发电量、损伤组件性能减少组件使用寿命。大恒全面屏组件相比普通组件, 等效小时数 (kWh/kW 发电量) 增益达 11.50%, 体现出了全面屏正面无边框设计在避免光伏组件底部积灰、抗灰尘遮挡损失方面的明显优势。

The rooftops with small-angle installation conditions would form the bottom soiling due to the nature rain wash and the altitude intercept between the regular PV module frame and glass. This problem is the primary reason that causes the shade and hotspots on commercial and household PV stations. This bottom soiling could form a “shading belt” with different widths. At some extreme conditions, the “shading belt” could completely

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cover the PV module, which will decrease the power generation, harm the PV module generation capacity, and shorten the life span of the PV module. Compared with the regular module, the Full-Screen PV module could increase power generation by 11.50% in the equivalent period. This experiment illustrates the Full-Screen PV Module with the front A-side frameless design, which could avoid the bottom soiling and decrease the shadow shading caused power generation loss.