

Output Performance of TOPCon and PERC Module by TÜV Nord in Malaysia

To compare the difference in energy yield between different types of PV modules, TOPCon and PERC bifacial under the outdoor environment, a field test study had been conducted by TÜV Nord in Malaysia during the period 01/01/2023 - 03/31/2023.

According to the test result, when comparing normalized energy yield gain, 182 TOPCon bifacial module is **5.69%** higher than that of 182 PERC bifacial module. Comparing the influence of different cell size on energy yield, the normalized energy yield of 210 PERC bifacial module is 0.98% lower than that of 182 PERC bifacial module.

1 DEMONSTRATION PROJECT OVERVIEW

1.1 SYSTEM INTRODUCTION

This project is located in the PV Field Trial Base in Selangor region, Malaysia. Selangor region has a typical tropical rainforest climate, with an average temperature of 28.2 °C, extreme maximum temperature of 38.5 °C, and annual rainfall of 2628 mm.

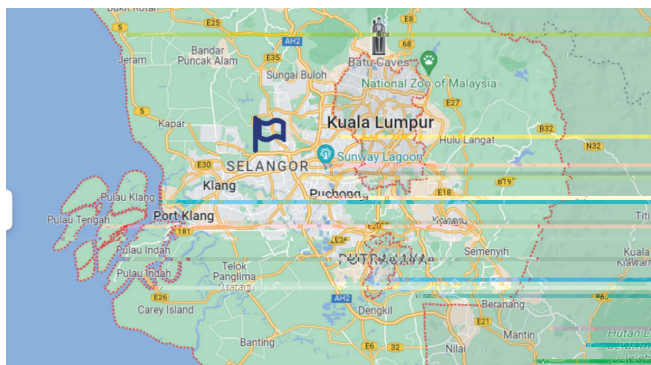


Figure 1. Location of the power station on Google Map

6 pieces of three types of module, 182 TOPCon bifacial module type, 182 PERC bifacial module type and 210 PERC bifacial module type, were installed in fixed 1P shape and connected to the grid with HM-1500 micro-inverters. The basic module information is shown as below.

Product Name	Nominal Power	Module Type	Test Module Quantity
182 TOPCon bifacial	545W	JKM545N-72HL4-BDV	2
182 PERC bifacial	540W	JKM540M-72HL4-BDVP	2
210 PERC bifacial	645W	N/A	2

The output terminal of each module is implanted with high-precision sensors to monitor the modules' power generation parameters in real time, and the data is aggregated and calculated through Alibaba Cloud platform digital monitoring system. In addition, the cloud platform digital monitoring system can realize the monitoring of real-time meteorological data of the demonstration site, and can also calculate the performance ratio of the theoretical and actual power generation of the photovoltaic system. All the power generation test data, meteorological data and data filtering provided in this report are completed by Python programs, so as to improve the speed of data processing and reduce the inefficiency, complexity and error-prone of manual Excel processing.

Main information of the field trial system is listed in the table below.

Project Location	PV Field Trial Base in Selangor Region, Malaysia
GPS Coordinate	3°2' N, 101°47' E
Annual Sun Exposure Hours	2222.3 h
Annual Global Horizontal Irradiation	5756.4 MJ/m2
Annual Average Temperature	28.2 °C
Annual Average Relative Humidity	81%
Date of Grid-connection	December 2022
Installation Method	Fixed 1P, 10°
Azimuth Angle	Due south, 0°
Height Above Ground	1m
Surface Condition	Concrete surface

1.2 MODULE INITIAL LABORATORY POWER

HALM solar simulator was used to test the modules' initial laboratory electrical performance parameters. The initial laboratory power of the 6 test modules is shown in the table below.

Module Type	Module Number	Serial Number	Pm (W)
JKM545N-72HL4-BDV	01	E3FXJ1220529610003868729	548.70
	02	E3FXJ1220529610003868860	549.17
JKM540M-72HL4-BDVP	03	E3XXF2220607180074875160	542.87
	04	E3XXF2220609180075820880	544.61
210 PERC bifacial module	05	N/A	650.59
	06	N/A	650.08

1.3 EQUIPMENT CONFIGURATION INFORMATION

The test equipment mainly includes custom-built data acquisition system for lab-quality DC monitoring at the module-level and multi-sensor weather station and irradiance sensor for meteorological monitoring. Monitoring system configurations are shown below. The test data acquisition interval is 5 seconds. The data recording period is 1 minute. The data acquisition accuracy of all the following equipment can meet the requirements of field trial. The module-level monitoring equipment and multi-sensor weather station connect to the data acquisition equipment through several RS485 communication cables. The data acquisition equipment can achieve stable data transmission, local storage and remote upload to Alibaba Cloud platform using 4G wireless network.

Equipment Category	Measurement parameter	Unit	Sensor type	Accuracy
Module-level monitoring equipment	DC voltage	V	Acrel	±0.5%
	DC current	A		±0.5%
	DC power	W		±0.4%
Multi-sensor weather station	Module temperature	°C	T-type thermocouple	±0.3 °C
	In-plane frontal irradiance	W/m²	Kipp&Zonen CMP10	0.2%
	Atmospheric pressure	Pa	SONBEST SM2182B	±2%
	Wind speed	m/s	Metone034B windsensor	±1.1%
	Wind direction	°		±4°
	Ambient temperature	°C	Campbell CS215 temperature / RH probe	±0.4 °C
	Relative humidity	%		±4%
Data acquisition equipment	Rainfall	mm	SR 50A CSE sonic ranging sensor	0.25mm
	—	—	Campbell CR1000Xsensor	—

