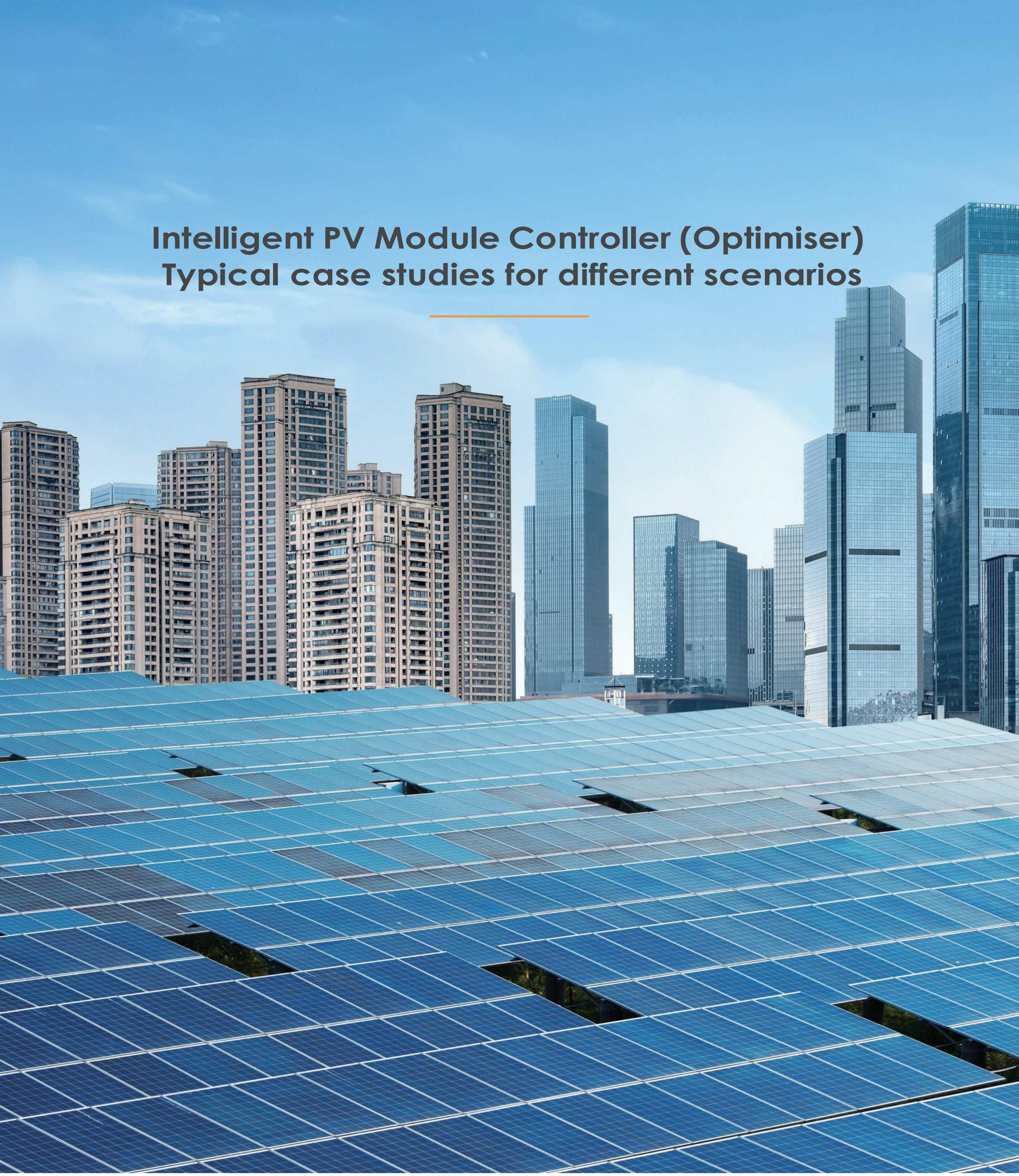
Intelligent PV Module Controller (Optimiser)
Typical case studies for different scenarios



GO WITH SUNSHINE

Avoiding the barrel effect, solving the problems of shadow shading and component mismatch, and improving the overall power generation of the system

1.1 Typical scene without fixed shadow occlusion

The scenario usually has no fixed shading occlusion, but there are random occlusions such as clouds, bird droppings, fallout, dust, etc., and such random occlusions result in a mismatch loss of about 2.5%. The following is an empirical example of power generation enhancement in a scenario without fixed shading.

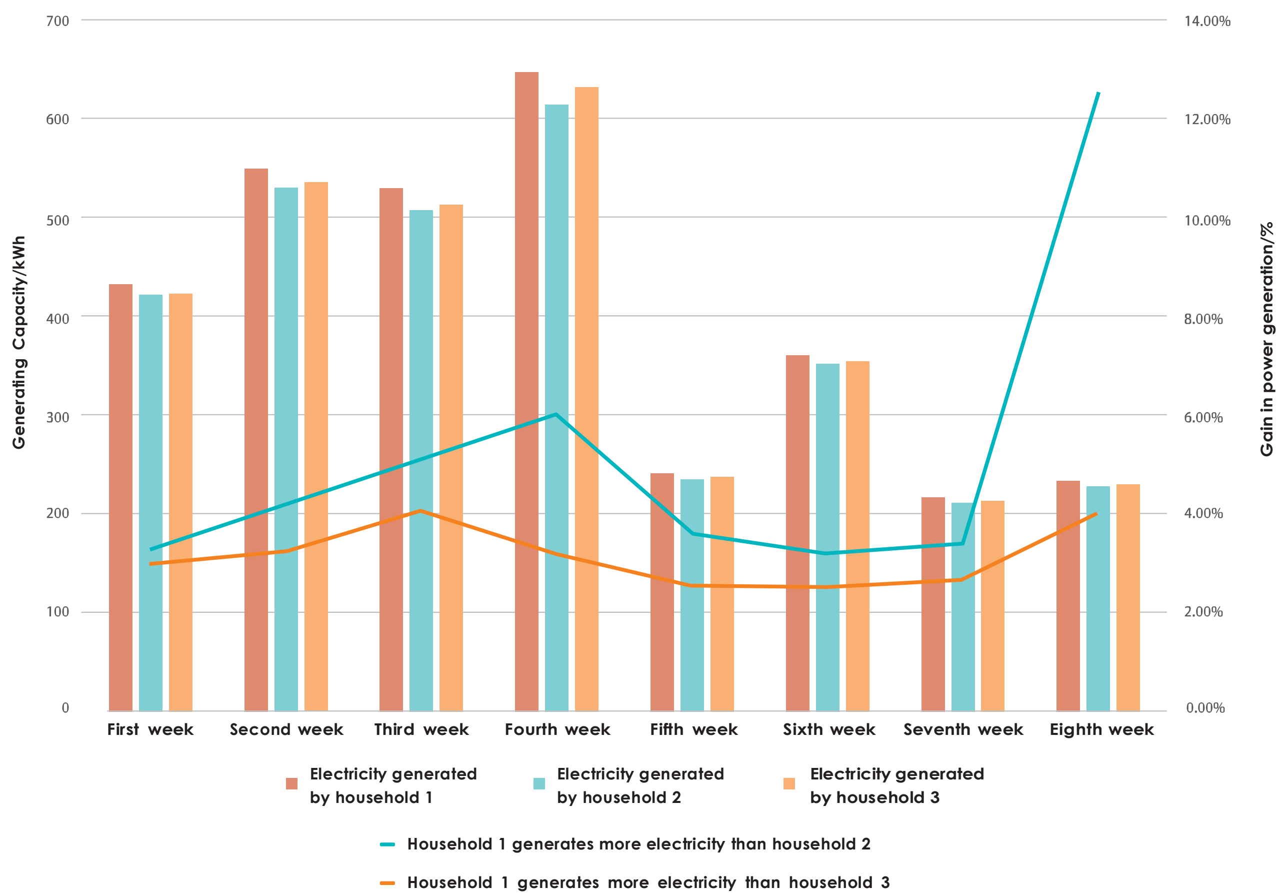
Test Location: Taixing Household Rooftop

Test Programme

Basic situation	The rural household rooftop PV system in Taixing, which was put into operation in early December 2023, Is a typical household without fixed shadow shading scenario, with three farmers' houses arranged in a single line in an east-west direction, with the same PV system orientation and tilt angle, and all of them have been fitted with corrected AC meters from the grid company. The capacity of all three systems is 8.8kW, with 16 modules, using 550W monocrystalline modules with Trina inverters.
Test method	A comparative experiment was used, choosing the east side households as the experimental group with full optimiser and the remaining households as the control group without optimiser.
Testing process	After confirming that the system has been debugged, the formal testing begins, and the inverter experimental data is observed and monitored through the management system to ensure the stability of the system connection and good communication. At the same time, record the weather during the test phase, such as light, temperature and other conditions.
Test cycle	December 05, 2023 to January 30, 2024, 57 days.

Results and analyses of the test

Throughout the test cycle, based on meter data, the first rooftop PV home with the optimiser generated 7.56% and 3.73% more electricity compared to the other two homes, respectively.



1.2 Typical building roof scene (partially obscured by fixed shading)

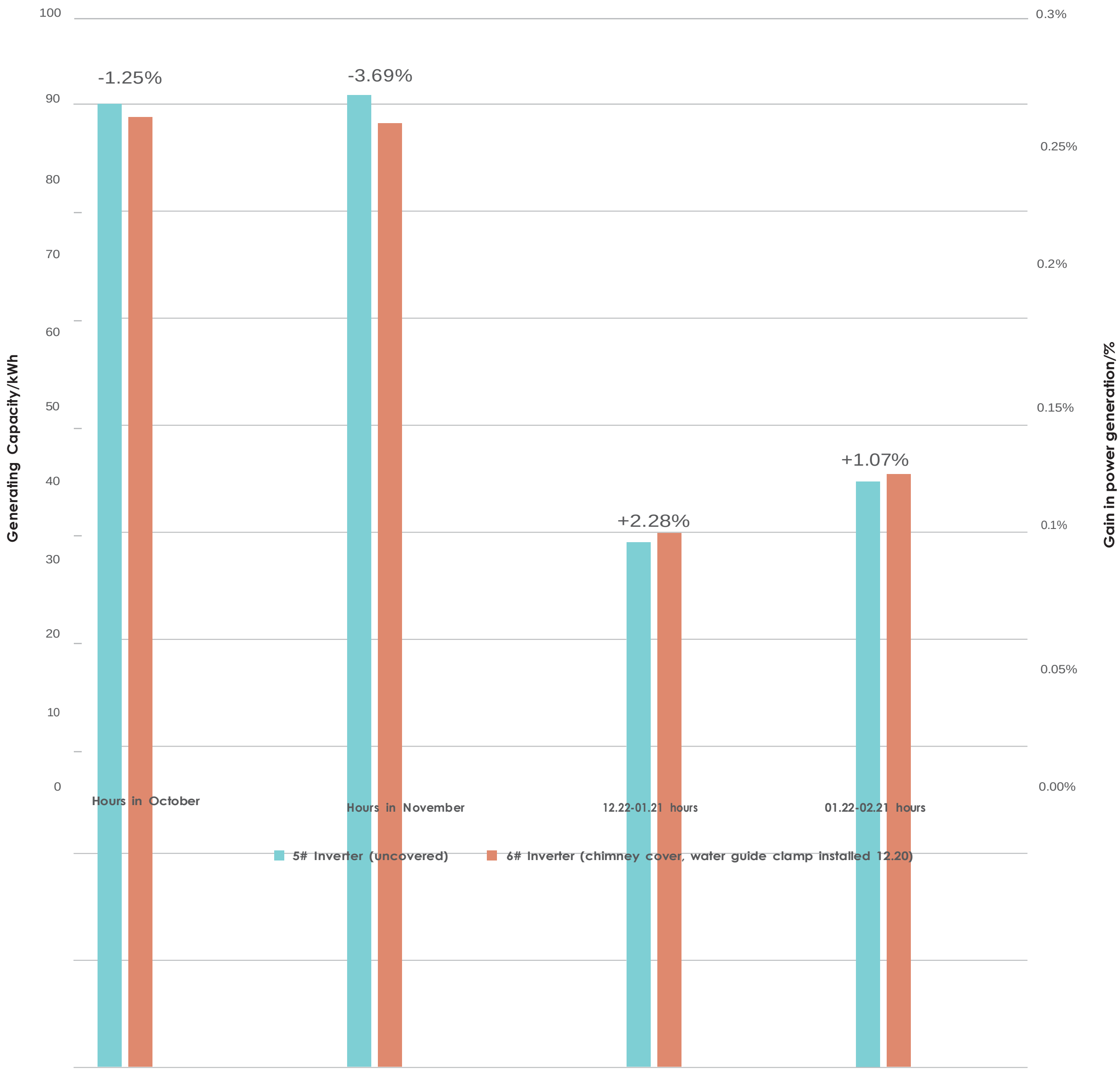
Test site: Rooftop of an industrial plant in Anhui Province

Test Programme

Basic situation	The owner installed nine large chimneys on the south side of the modules, causing shadows to block the modules, which seriously affected the power generation of the modules. The PV modules and inverters installed in the whole station are all of the same type, and the external influence is minimised under this condition. Two inverters of 121kW each, totalling 140 modules, were selected as controls for the experiment.
Test method	A control experiment is taken, the module installation optimiser of 6# inverter with severe shadow shading is selected, and the module of 5# inverter with no shadow shading is used as a comparison, and another comparison of power data before and after installation is carried out between 6# inverter and 5# inverter after installation.
Testing process	Beginning of the test, the arrangement of a person to record the AC meter power generation, management system to observe the inverter experimental data, the test process has been carried out on the inverter and branch circuit inspection, equipment and branch circuit are no fault.
Test cycle	22 December 2023 to 21 February 2024

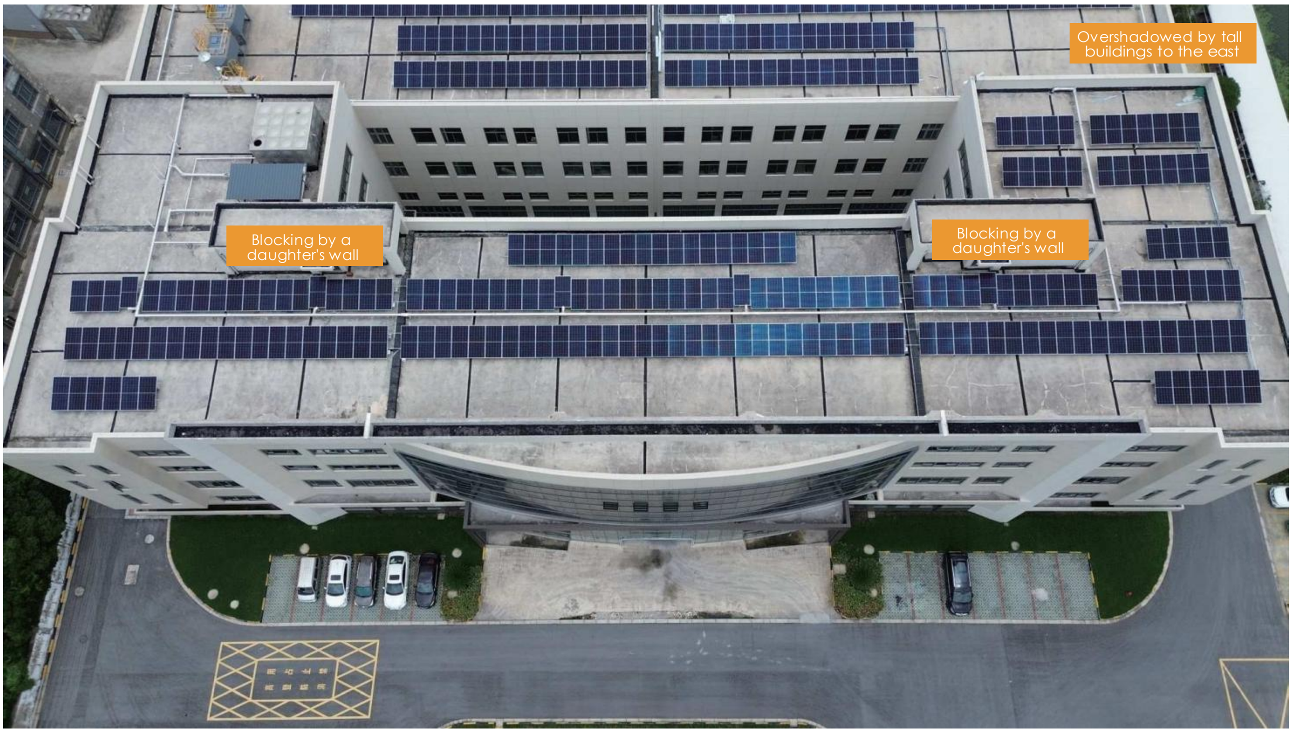
Results and analyses of the test

By looking at the monthly hourly data comparison between pre-installation (October and November) and post-installation (January and February), the average increase in power generation after the installation of the 6# inverter was 4%.



1.3 Typical commercial and industrial roofing scenarios

Test Location: An industrial plant in Changshu



Test Programme

Basic situation	The roof is a conventional solution. 345 pieces of 550W modules were used with a DC capacity of 189.8kWp, and the project has been in operation for about 2 years. Project The initial planning to ensure the installed capacity, unavoidable wall shadow shading, high building shadow shading, ventilation pipe shadow shading, etc., the power generation is obviously low.
Test method	A benchmarking plus comparison testing scheme was used. Firstly, a calibrated meter is installed at the output of each inverter for benchmarking, and then all the components belonging to the one with the lowest single kW power generation hours are selected to be fitted with optimisers, and then the verification test for power generation improvement is completed.
Testing process	Three inverter systems were selected for testing, numbered #1 to #3. The baseline test was carried out for 1 month, and based on the AC meter recording of power generation data, the #1 inverter system with the highest loss of power generation in this real environment was selected as the experimental group, and the rest were the control group, and a power generation enhancement verification test was carried out to record the daily meter power generation, and the data were recorded and statistically analysed.
Test cycle	Baseline testing: 15 December 2022 to 08 February 2023 Formal testing: 14 February 2023 to 15 March 2023

Results and analyses of the test

After the completion of the test, the data statistics were conducted for the benchmark test and the formal test respectively, and the results are shown in the table below:

Benchmarking phase	Experimental group single kW power generation h	94.67	
	Control group single kW power generation h	124.76	122.60
	Comparison ratio %	-24 1%	-22.8%
Optimizer testing phase	Experimental group single kW power generation h	115.76	
	Control group single kW power generation h	93.74	107.91
	Comparison ratio %	23.5%	7.3%
Percentage of upgrading %		47.6%	30.1%

1.4 Typical power station that has been in operation for a long time (5+ years old modules)

Test site: an above-ground power station in Japan

Test Programme

Basic situation	This rooftop PV project has been in operation for more than 5 years. Three sets of inverter systems were selected for the test, each string of 12 modules with 250W polycrystalline modules, i.e., 12kW of PV modules per inverter. Due to the long commissioning time, there are potential impact factors on the power generation, such as random environmental shadow shading, module attenuation mismatch, local hot spots, and breakage.
Test method	A programme of benchmarking and verification testing for power generation improvement was used. Benchmarking was carried out first, and formal optimiser testing was carried out after the optimiser was added to systems with lower generation.
Testing process	Confirmation of the system debugging is completed to start the formal test, through the management system to observe and monitor the inverter experimental data, to ensure the stability of the system connection and good communication. At the same time, record the weather during the test phase, such as light, temperature and other conditions.
Test cycle	Baseline testing: 17 November to 17 December 2023; Formal testing: Phase I - 18 December 2023 to 31 December 2023; Phase II – 1 January 2024 to 19 February 2024

Results and analyses of the test

Before the installation of the optimiser

The average single-day generation of string #3 was about 85.47% of the average single-day generation of string #1 and about 91.75% of the average single-day generation of string #2.

After the optimiser has been installed

Phase I: The average single-day generation of string #3 is about 89.46% of the average single-day generation of string #1 and about 96.07% of the average single-day generation of string #2.

Phase II: The average daily generation of string #3 continued to improve to about 95.4% of that of string #1 and about 98.8% of that of string #2. The comprehensive assessment shows that the problematic strings were improved by about 9.5% in about 2 months by replacing the Sungo Optimiser.

Comparative analysis of the economics of typical projects in various scenarios

The main revenue of PV projects comes from the electricity tariffs generated by PV power generation. For household scenarios, a "full feed-in" model is usually adopted, generating revenue based on the grid company's feed-in tariff. For industrial and commercial scenarios, the "self-generation and self-consumption, with the remaining power going online" model is usually adopted to improve the consumption and self-generation and self-consumption rate of PV power generation, thus increasing the revenue. Levelised Cost of Electricity (LCOE) = (initial investment – present value of tax relief due to depreciation during the life cycle + present value of costs due to project operation during the life cycle – present value of residual value of fixed assets) / (present value of electricity generation during the life cycle), i.e. the cost of generating one unit of green electricity. Based on the tariffs and costs of PV projects, combined with the initial investment in the system and the annual O&M costs during operation, a full life-cycle project cash flow statement can be obtained, from which the economics of the PV project can be calculated, e.g. IRR and payback period.

Typical project economics for residential scenarios

Typical Projects for Residential Scenarios	Traditional Programs	SUNGO Optimizer program (no multi-loading)	SUNGO Optimizer program (with multiple installations)
Roof area	120m²	120m²	120m²
PV selection	500 W	500 W	500 W
DC capacity	24 kWp	24 kWp	26.4 kWp
AC capacity	20 kW	20 kW	20 kW
Hours of power generation in the first year	1200 h	1266 h	1255 h
Whether to configure the optimizer	No	Yes	Yes
Feed-in tariffs	0.3757 yuan /kWh	0.3757 yuan /kWh	0.3757 yuan /kWh
Electricity tariffs	0.5 Yuan /kWh	0.5 yuan /kWh	0.5 yuan /kWh
Self-generated self-utilization rate	0%	0%	0%
Unit cost of electricity	0.2837 yuan /kWh	0.2798 yuan /kWh	0.2823 yuan /kWh
Internal rate of return (IRR)	7.42%	7.67%	7.55%
Recovery period	10.84 years	10.61 years	10.73 years
Life cycle generation	67.84 ten thousand kWh	71.57 ten thousand kWh	78.02 ten thousand kWh
Gross life cycle income	25.49 ten thousand yuan	26.89 ten thousand yuan	29.31 ten thousand yuan
Carbon dioxide emission reductions*	322.25 ton	339.97 ton	370.6 ton

* Calculated on the basis of 0.475 kg CO_2 emission reduction per 1 kWh of green electricity.

Party & Government Organizations / Public Buildings Scenario Typical Project Economy Measurement

Party & Government Organizations / Public Buildings Scenarios Typical Projects	Traditional Programs	SUNGO Optimizer program (no multi-loading)	SUNGO Optimizer program (with multiple installations)
Roof area	10000m^2	10000m^2	10000m^2
PV selection	500 W	500 W	500 W
DC capacity	1 MW	1 MW	1 MW
AC capacity	880 kW	880 kW	880 kW
Hours of power generation in the first year	1200 h	1200 h	1200 h
Whether to configure the optimizer	No	Yes	Yes
Feed-in tariffs	0.3757 yuan /kWh	0.3757 yuan /kWh	0.3757 yuan /kWh
Electricity tariffs	0.7 yuan /kWh	0.7 yuan /kWh	0.7 yuan /kWh
Self-generated self-utilization rate	60%	60%	60%
Unit cost of electricity	0.285 yuan /kWh	0.281 yuan /kWh	0.2875 yuan /kWh
Internal rate of return (IRR)	13.56%	13.68%	13.3%
Recovery period	6.54 years	6.49 years	6.67 years
Life cycle generation	2826.7 ten thousand kWh	2982.18 ten thousand kWh	3788.65 ten thousand kWh
Gross life cycle income	1611.2 ten thousand yuan	1670 ten thousand yuan	2160 ten thousand yuan
Carbon dioxide emission reductions*	13427 ton	14165 ton	17996 ton

* Calculated on the basis of 0.475 kg CO_2 emission reduction per 1 kWh of green electricity.

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