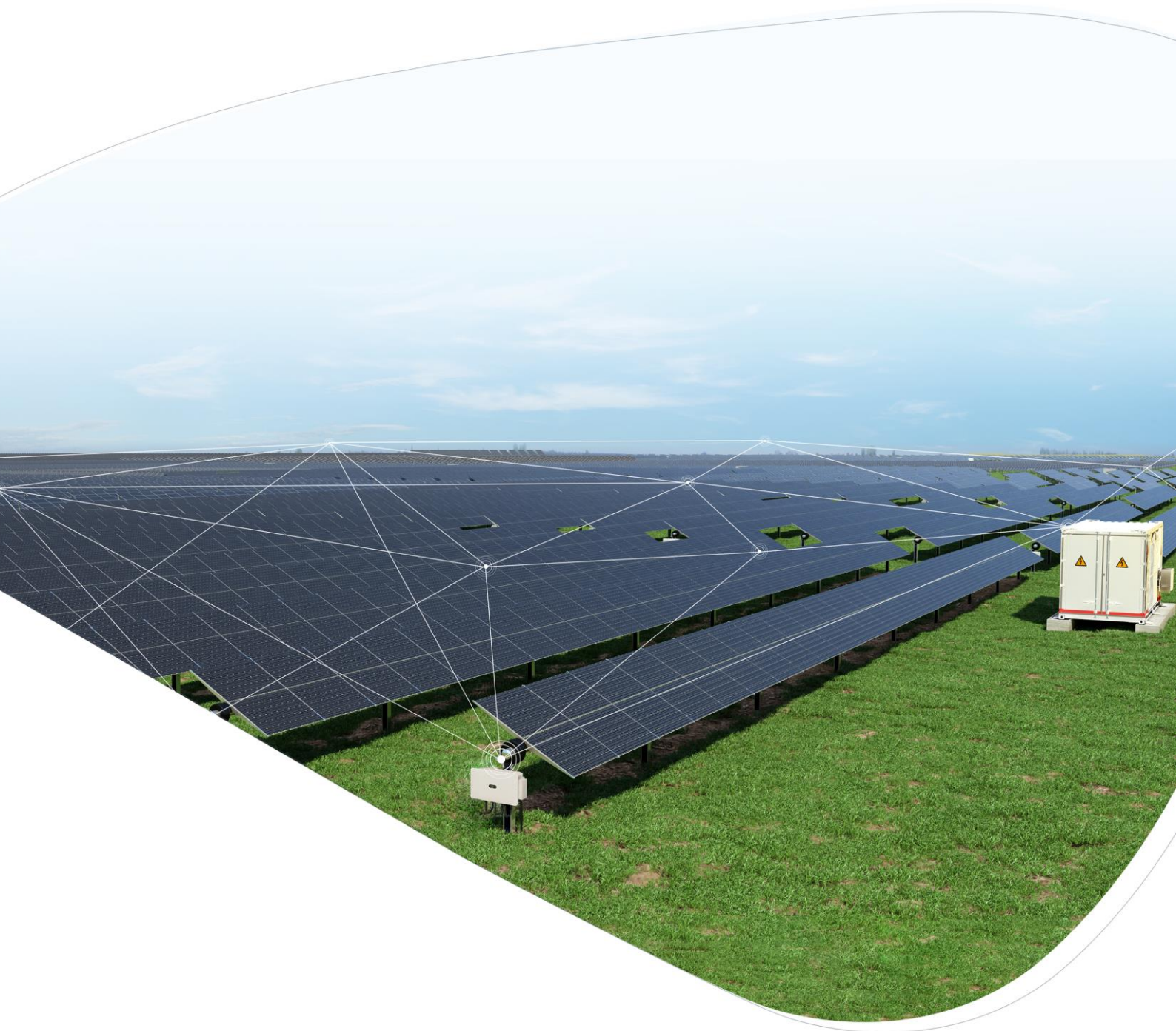




FusionSolar[®]

Smart I-V Curve Diagnosis Report

50MW PV Plant

Smart I-V Curve Diagnosis

Overview Report

Inspection Plant:_____

Inspection On:_____

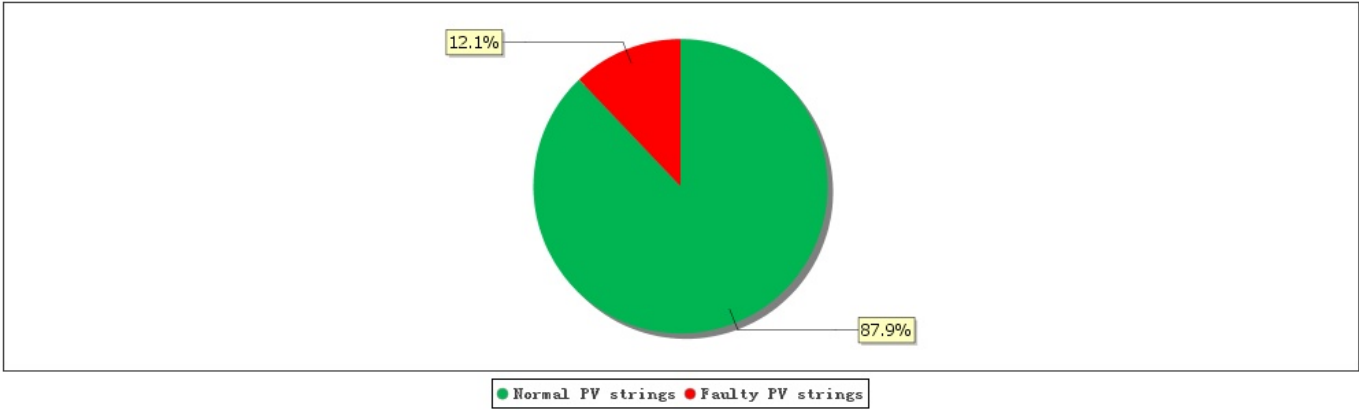
Inspection By:_____

Owner Company

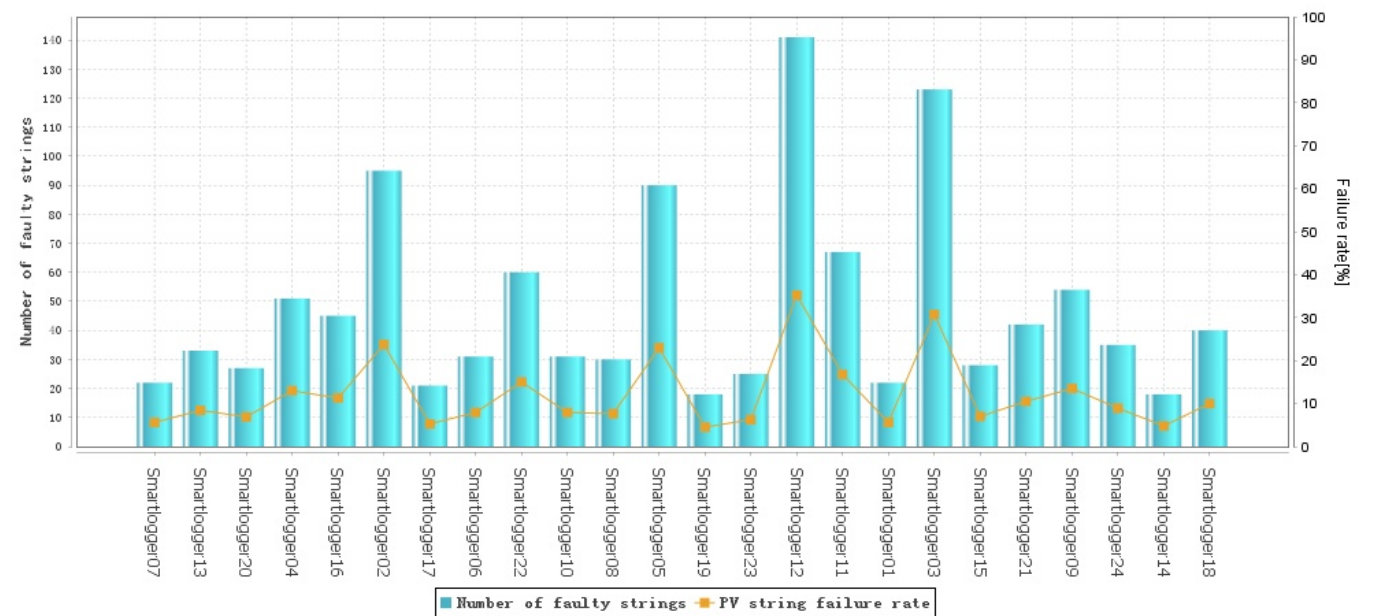
Project name: 50MW PV Plant
Owner: Company A
Design institute: Company B
Construction company: Company C
Acceptance organization: Company A
Installation/Operation date: 08/02/2018
Construction address: Munich
GPS coordinates: latitude48°08', longitude11°35'
Altitude(m): 515
Total annual radiation(kWh/m²): approx. 1755
Annual average temperature(℃): 18
Highest extreme temperature(℃): 30
Lowest extreme temperature(℃): -5

1. Evaluation of the PV String Failure Rate

In total, 9496 PV strings are scanned in this task. Faulty PV strings: 1149Total failure rate: 12.1%



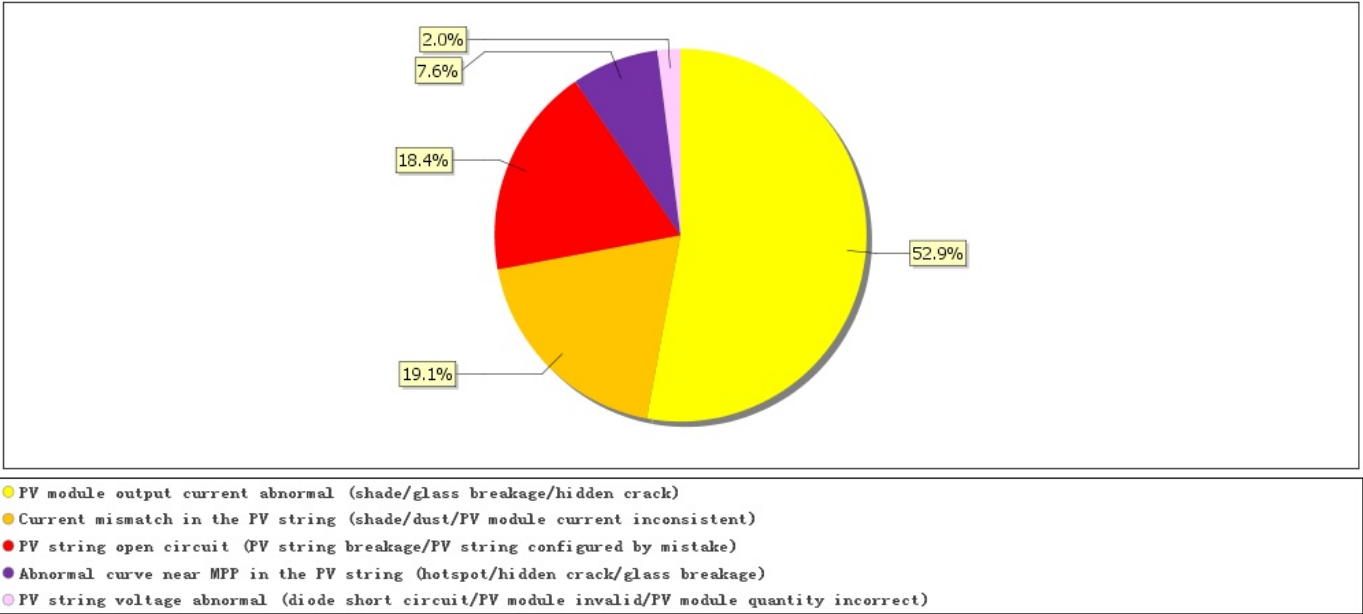
No.	SmartLogger Name	Manufacturer of Module	Module Type	Total number of strings	Number of faulty strings	Failure rate
1	Smartlogger07	XXXXXXXX	XXXXXXXX	392	22	5.6%
2	Smartlogger13	XXXXXXXX	XXXXXXXX	392	33	8.4%
3	Smartlogger20	XXXXXXXX	XXXXXXXX	392	27	6.9%
4	Smartlogger04	XXXXXXXX	XXXXXXXX	392	51	13.0%
5	Smartlogger16	XXXXXXXX	XXXXXXXX	400	45	11.2%
6	Smartlogger02	XXXXXXXX	XXXXXXXX	400	95	23.8%
7	Smartlogger17	XXXXXXXX	XXXXXXXX	400	21	5.2%
8	Smartlogger06	XXXXXXXX	XXXXXXXX	392	31	7.9%
9	Smartlogger22	XXXXXXXX	XXXXXXXX	400	60	15.0%
10	Smartlogger10	XXXXXXXX	XXXXXXXX	392	31	7.9%
11	Smartlogger08	XXXXXXXX	XXXXXXXX	392	30	7.7%
12	Smartlogger05	XXXXXXXX	XXXXXXXX	392	90	23.0%
13	Smartlogger19	XXXXXXXX	XXXXXXXX	400	18	4.5%
14	Smartlogger23	XXXXXXXX	XXXXXXXX	400	25	6.2%
15	Smartlogger12	XXXXXXXX	XXXXXXXX	400	141	35.2%
16	Smartlogger11	XXXXXXXX	XXXXXXXX	400	67	16.8%
17	Smartlogger01	XXXXXXXX	XXXXXXXX	392	22	5.6%
18	Smartlogger03	XXXXXXXX	XXXXXXXX	400	123	30.8%
19	Smartlogger15	XXXXXXXX	XXXXXXXX	400	28	7.0%
20	Smartlogger21	XXXXXXXX	XXXXXXXX	400	42	10.5%
21	Smartlogger09	XXXXXXXX	XXXXXXXX	400	54	13.5%
22	Smartlogger24	XXXXXXXX	XXXXXXXX	392	35	8.9%
23	Smartlogger14	XXXXXXXX	XXXXXXXX	376	18	4.8%
24	Smartlogger18	XXXXXXXX	XXXXXXXX	400	40	10.0%



2. Fault Type Analysis

In total, 24 SmartLoggers are scanned in this task,1149 PV strings are faulty. The distribution is as follows: The common faults are:

- 1) PV module output current abnormal (shade/glass breakage/hidden crack), Percentage: 52.9%
 - 2) Current mismatch in the PV string (shade/dust/PV module current inconsistent), Percentage: 19.1%
 - 3) PV string open circuit (PV string breakage/PV string configured by mistake), Percentage: 18.4%
- First 3 common faults vs. total faults:90.4%



Fault type	Number of faulty strings	%
PV module output current abnormal (shade/glass breakage/hidden crack)	608	52.9%
Current mismatch in the PV string (shade/dust/PV module current inconsistent)	220	19.1%
PV string open circuit (PV string breakage/PV string configured by mistake)	211	18.4%
Abnormal curve near MPP in the PV string (hotspot/hidden crack/glass breakage)	87	7.6%
PV string voltage abnormal (diode short circuit/PV module invalid/PV module quantity incorrect)	23	2.0%

50MW PV Plant Smartlogger01 Smart I-V Curve Diagnosis

Inspection Plant:_____

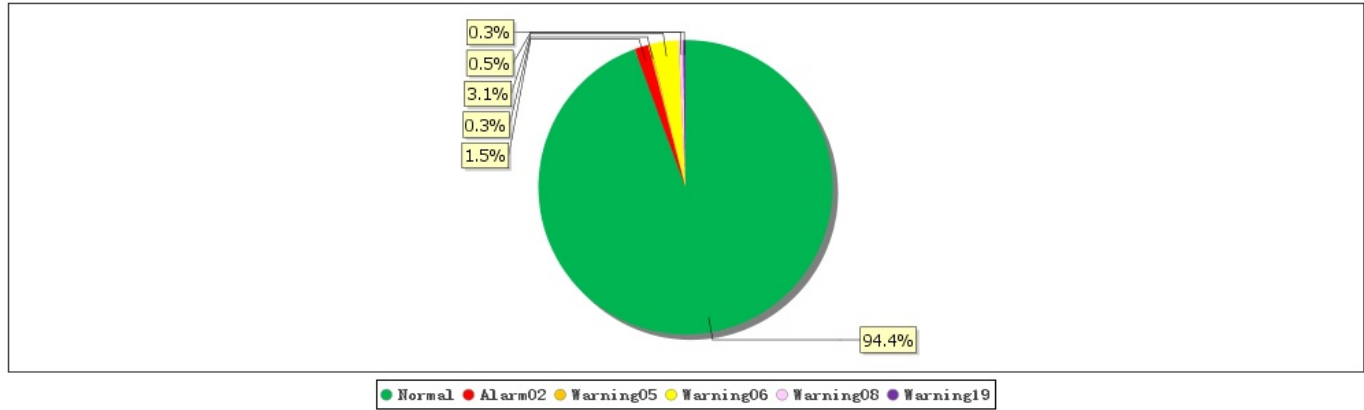
Inspection On:_____

Owner Company

1. Information of Task

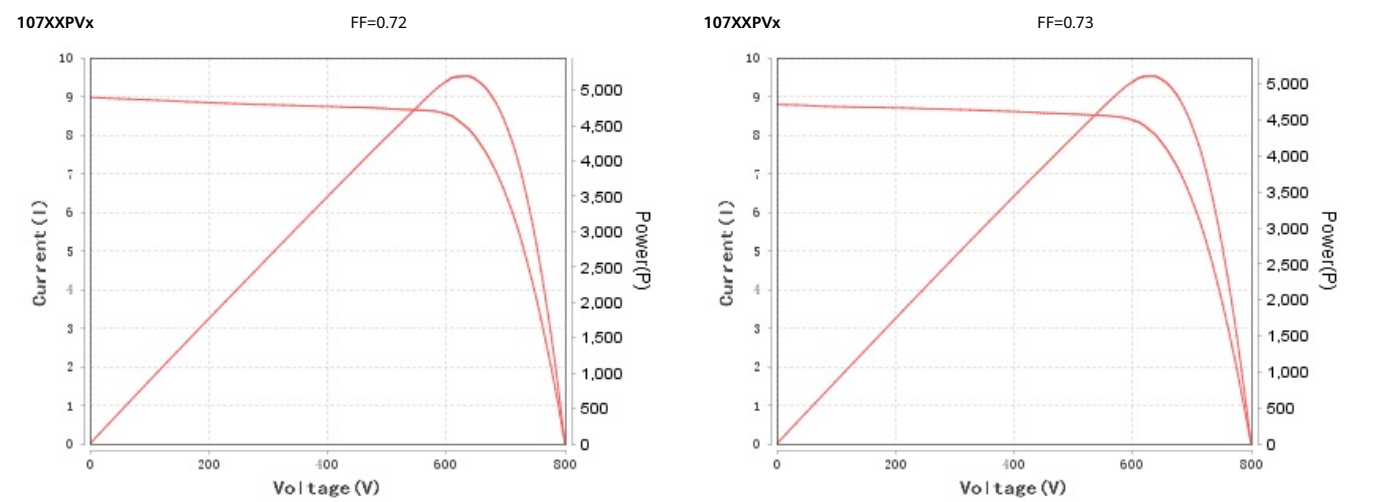
Task name	CASE2 Plant 50MW	Creation Time	2018-12-22 12:17:32
Cleaning status	Uncleaned	Task type	PV plant level diagnosis
Total number of strings	392	Number of faulty strings	22
Irradiance(W/m²)	967.15(Predictive value)	Temperature Of Panel(°C)	64.62(Predictive value)

2. Overview on Diagnosis



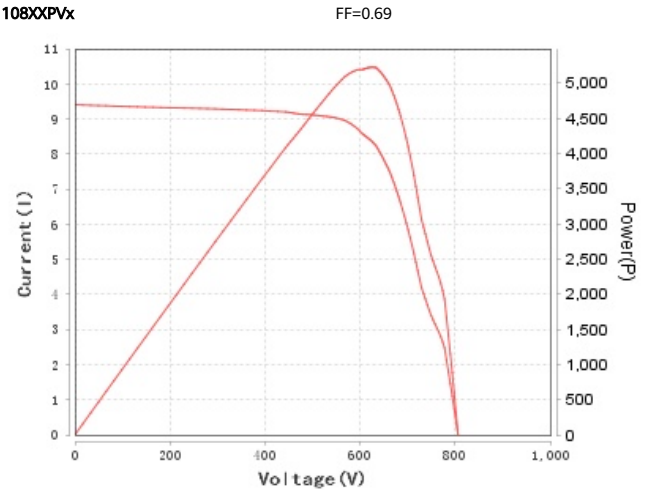
Legend	Quantity	Percentage	Description
Normal	370	94.4%	PV string normal
Alarm02	6	1.5%	PV string open circuit (PV string breakage/PV string configured by mistake)
Warning05	1	0.3%	Current mismatch in the PV string (shade/dust/PV module current inconsistent)
Warning06	12	3.1%	PV module output current abnormal (shade/glass breakage/hidden crack)
Warning08	2	0.5%	PV string voltage abnormal (diode short circuit/PV module invalid/PV module quantity incorrect)
Warning19	1	0.3%	Abnormal curve near MPP in the PV string (hotspot/hidden crack/glass breakage)

3. PV String I-V Curve Details

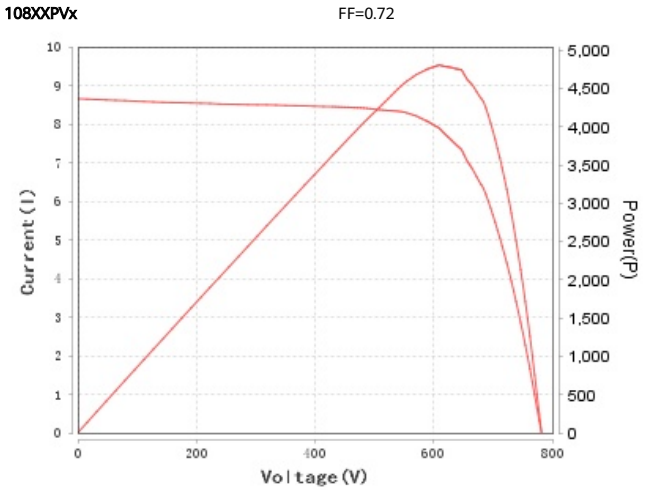


Isc[A]	8.97	Imp[A]	8.15	Pmax[W]	5199.98
Voc[V]	799.70	Vmp[V]	637.80	PV string normal	
Irr[W/m²]	967.15	Temp[°C]	64.62		

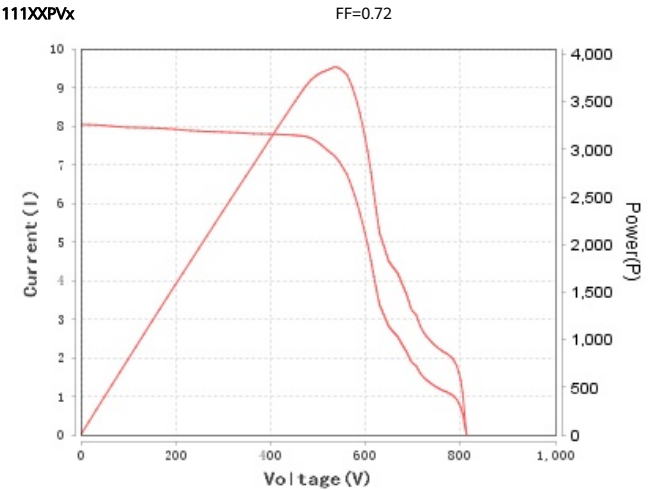
Isc[A]	8.79	Imp[A]	8.09	Pmax[W]	5110.63
Voc[V]	799.70	Vmp[V]	631.80	PV string normal	
Irr[W/m²]	967.15	Temp[°C]	64.62		



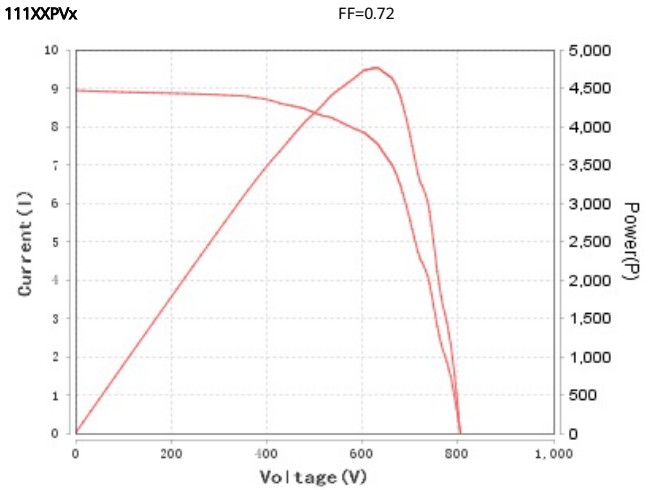
Isc[A]	9.40	Imp[A]	8.36	Pmax[W]	5224.58
Voc[V]	806.20	Vmp[V]	624.80	PV module output current abnormal (shade/glass breakage/hidden crack)	
Irr[W/m²]	967.15	Temp[°C]	64.62		



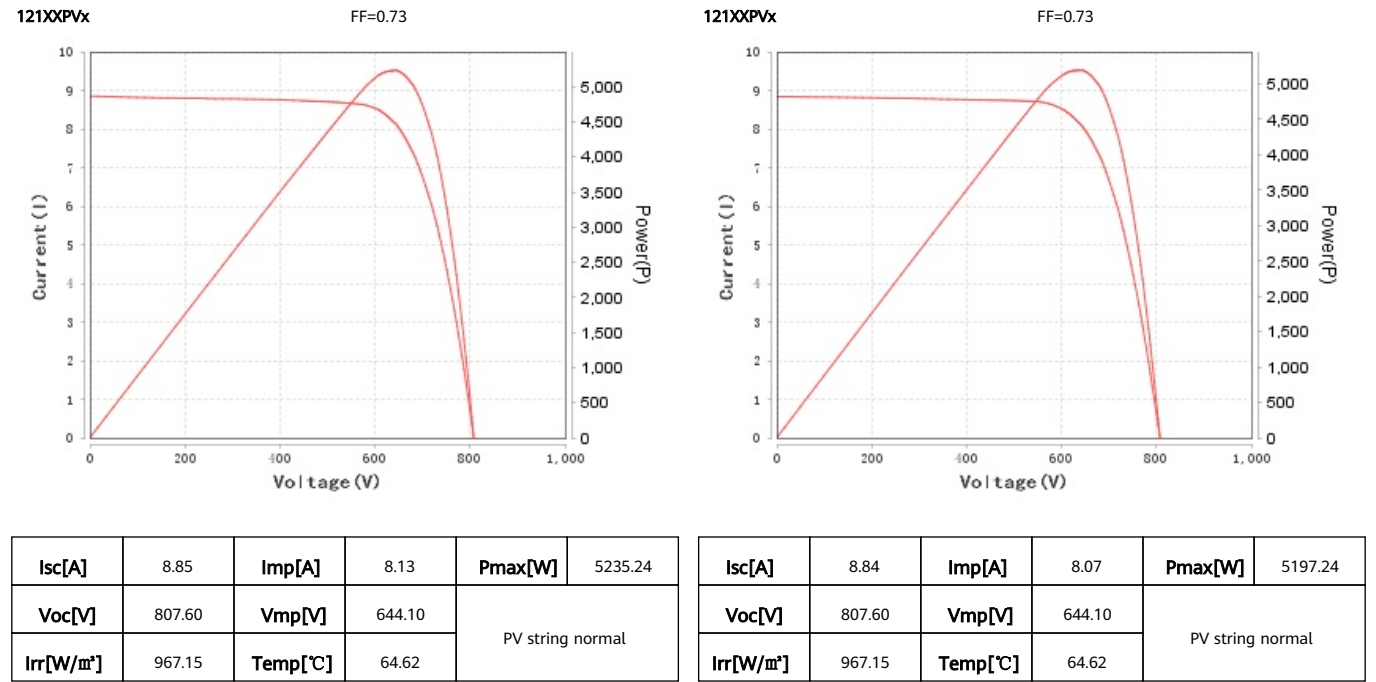
Isc[A]	8.65	Imp[A]	7.88	Pmax[W]	4808.63
Voc[V]	782.00	Vmp[V]	610.00	PV string voltage abnormal (diode short circuit/PV module invalid/PV module quantity incorrect)	
Irr[W/m²]	967.15	Temp[°C]	64.62		



Isc[A]	8.04	Imp[A]	7.24	Pmax[W]	3863.64
Voc[V]	812.80	Vmp[V]	533.80	PV module output current abnormal (shade/glass breakage/hidden crack)	
Irr[W/m²]	967.15	Temp[°C]	64.62		



Isc[A]	8.94	Imp[A]	7.54	Pmax[W]	4766.16
Voc[V]	805.30	Vmp[V]	632.20	Current mismatch in the PV string (shade/dust/PV module current inconsistent)	
Irr[W/m²]	967.15	Temp[°C]	64.62		



4. PV String Performance Data Details

Task time:2018-12-22 12:17:32

Note: The irradiance and PV module temperatures used by the STC conversion model are data deduced and converted based on the mathematical model. The data is of referential use only and cannot be used as basis for PV module evaluation.

Inverter	String	Test Data						*STC Conversion						Irr[W/m²]	Temp[°C]	Determination
		Pmax[Wp]	Voc[V]	Isc[A]	FF	Vmp[V]	Imp[A]	Pmax[Wp]	Voc[V]	Isc[A]	FF	Vmp[V]	Imp[A]			
10701	PV1	5199.98	799.70	8.97	0.72	637.80	8.15	6105.92	912.56	9.09	0.74	737.85	8.28	967.15	64.62	✓
	PV2	5110.63	799.70	8.79	0.73	631.80	8.09	6004.24	913.40	8.90	0.74	731.78	8.21	967.15	64.62	✓
	PV3	5240.24	804.30	9.01	0.72	641.40	8.17	6149.45	917.63	9.13	0.73	741.46	8.29	967.15	64.62	✓
	PV4	5221.12	804.30	9.00	0.72	633.40	8.24	6136.82	917.71	9.11	0.73	733.54	8.37	967.15	64.62	✓
	PV5	5325.38	802.90	9.08	0.73	640.30	8.32	6252.09	915.73	9.20	0.74	740.51	8.44	967.15	64.62	✓
	PV6	5318.33	802.90	9.15	0.72	640.30	8.31	6245.66	915.42	9.27	0.74	740.50	8.43	967.15	64.62	✓
	PV7	5508.33	803.90	9.43	0.73	641.10	8.59	6473.97	915.36	9.55	0.74	741.60	8.73	967.15	64.62	✓
	PV8	5351.12	803.90	9.21	0.72	629.10	8.51	6300.29	916.29	9.33	0.74	729.50	8.64	967.15	64.62	✓
12401	PV1	5124.56	814.40	8.67	0.73	649.50	7.89	5995.79	930.73	8.78	0.73	749.28	8.00	967.15	64.62	✓
	PV2	5132.92	814.40	8.83	0.71	631.20	8.13	6032.23	929.98	8.95	0.73	731.22	8.25	967.15	64.62	✓
	PV3	5271.28	811.40	8.85	0.73	647.10	8.15	6174.44	926.47	8.96	0.74	747.14	8.26	967.15	64.62	✓
	PV4	5038.97	811.40	8.68	0.72	647.10	7.79	5899.05	927.26	8.79	0.72	746.77	7.90	967.15	64.62	✓
	PV5	5018.38	806.60	8.56	0.73	643.30	7.80	5876.54	922.33	8.67	0.73	742.98	7.91	967.15	64.62	✓
	PV6	5249.33	806.60	8.98	0.72	643.30	8.16	6156.77	920.42	9.09	0.74	743.35	8.28	967.15	64.62	✓
	PV7	5305.36	809.40	9.05	0.72	645.50	8.22	6221.41	923.27	9.17	0.73	745.61	8.34	967.15	64.62	✓
	PV8	5171.10	809.40	8.76	0.73	645.50	8.01	6057.05	924.62	8.87	0.74	745.40	8.13	967.15	64.62	✓
10502	PV1	5009.19	802.10	8.82	0.71	649.70	7.71	5864.97	915.97	8.94	0.72	749.30	7.83	967.15	64.62	✓
	PV2	5216.75	802.10	9.00	0.72	639.70	8.15	6123.80	915.18	9.11	0.73	739.75	8.28	967.15	64.62	✓
	PV3	5195.52	802.50	8.92	0.73	640.00	8.12	6096.64	915.98	9.04	0.74	740.01	8.24	967.15	64.62	✓
	PV4	5171.32	802.50	8.88	0.73	636.00	8.13	6072.30	916.17	8.99	0.74	736.02	8.25	967.15	64.62	✓
	PV5	5177.39	801.90	8.84	0.73	639.50	8.10	6073.97	915.67	8.95	0.74	739.49	8.21	967.15	64.62	✓
	PV6	5223.77	801.90	9.01	0.72	631.50	8.27	6142.81	914.89	9.13	0.74	731.67	8.40	967.15	64.62	✓
	PV7	5439.41	803.80	9.42	0.72	635.00	8.57	6401.18	915.28	9.54	0.73	735.47	8.70	967.15	64.62	✓
	PV8	5166.88	803.80	8.95	0.72	625.00	8.27	6083.10	917.32	9.07	0.73	725.16	8.39	967.15	64.62	✓
10301	PV1	5221.24	812.50	8.84	0.73	633.80	8.24	6132.40	927.80	8.95	0.74	733.93	8.36	967.15	64.62	✓
	PV2	5065.41	802.40	8.66	0.73	625.90	8.09	5955.65	917.06	8.77	0.74	725.88	8.20	967.15	64.62	✓
	PV3	5247.88	805.20	8.96	0.73	642.10	8.17	6156.05	918.91	9.07	0.74	742.17	8.29	967.15	64.62	✓
	PV4	5166.34	805.20	8.84	0.73	642.10	8.05	6057.89	919.43	8.96	0.74	742.04	8.16	967.15	64.62	✓
	PV5	5173.32	803.10	8.89	0.72	640.50	8.08	6069.33	916.80	9.01	0.73	740.47	8.20	967.15	64.62	✓
	PV6	5225.66	803.10	9.02	0.72	636.50	8.21	6138.68	916.25	9.13	0.73	736.60	8.33	967.15	64.62	✓
	PV7	5346.07	804.30	9.23	0.72	641.40	8.34	6278.70	916.67	9.35	0.73	741.63	8.47	967.15	64.62	✓
	PV8	5316.59	804.30	9.20	0.72	627.40	8.47	6261.63	916.82	9.31	0.73	727.77	8.60	967.15	64.62	✓
10302	PV1	5215.03	813.50	8.80	0.73	636.60	8.19	6120.77	929.08	8.92	0.74	736.68	8.31	967.15	64.62	✓
	PV2	5183.22	804.90	8.87	0.73	635.90	8.15	6086.16	918.95	8.99	0.74	735.94	8.27	967.15	64.62	✓
	PV3	5273.35	808.70	8.92	0.73	644.90	8.18	6181.29	923.08	9.03	0.74	744.97	8.30	967.15	64.62	✓
	PV4	5258.51	808.70	8.94	0.73	644.90	8.15	6164.43	923.00	9.05	0.74	744.95	8.28	967.15	64.62	✓
	PV5	5204.97	807.70	8.82	0.73	644.10	8.08	6099.98	922.38	8.93	0.74	744.07	8.20	967.15	64.62	✓
	PV6	5313.47	807.70	9.13	0.72	640.10	8.30	6239.59	921.00	9.24	0.73	740.30	8.43	967.15	64.62	✓
	PV7	5497.40	807.90	9.40	0.72	636.20	8.64	6467.03	920.03	9.52	0.74	736.74	8.78	967.15	64.62	✓
	PV8	5279.08	807.90	9.05	0.72	634.20	8.32	6205.03	921.57	9.16	0.73	734.42	8.45	967.15	64.62	✓
10202	PV1	5229.51	809.10	8.87	0.73	645.30	8.10	6128.28	923.78	8.98	0.74	745.29	8.22	967.15	64.62	✓
	PV2	5243.06	809.10	8.97	0.72	645.30	8.12	6146.81	923.30	9.08	0.73	745.32	8.25	967.15	64.62	✓

50MW PV Plant Smartlogger01 PV string O&M report

Inspection Plant: _____

Inspection On: _____

Inspection By: _____

Owner Company

1. Information of Task

Task name	CASE2 Plant 50MW	Creation Time	2018-12-22 12:17:32
Cleaning status	Uncleaned	Task type	PV plant level diagnosis
Total number of strings	392	Number of faulty strings	22
Irradiance(W/m²)	967.15(Predictive value)	Temperature Of Panel(°C)	64.62(Predictive value)

2. Overview on Diagnosis

NO.	Inverter	Inverter (SN)	String	Voc[V]	Isc[A]	Defective type	Locate	Position of Faulty PV Module
1	10201	XX730246THB900XXX	PV8	-	-	PV string open circuit (PV string breakage/PV string configured by mistake)		
2	11402	XX730246THB900XXX	PV6	802.70	9.37	PV module output current abnormal (shade/glass breakage/hidden crack)		
3			PV8	-	-	PV string open circuit (PV string breakage/PV string configured by mistake)		
4	11801	XX730246THB900XXX	PV3	812.90	8.04	PV module output current abnormal (shade/glass breakage/hidden crack)		
5	10801	XX730246THB901XXX	PV3	806.50	9.01	PV module output current abnormal (shade/glass breakage/hidden crack)		
6			PV7	806.20	9.40	PV module output current abnormal (shade/glass breakage/hidden crack)		
7	10901	XX730246THB901XXX	PV1	805.30	8.94	PV module output current abnormal (shade/glass breakage/hidden crack)		
8			PV2	805.30	8.94	Current mismatch in the PV string (shade/dust/PV module current inconsistent)		
9	10102	XX730246THB901XXX	PV7	-	-	PV string open circuit (PV string breakage/PV string configured by mistake)		
10			PV8	-	-	PV string open circuit (PV string breakage/PV string configured by mistake)		
11	11602	XX730246THB901XXX	PV2	810.80	8.51	Abnormal curve near MPP in the PV string (hotspot/hidden crack/glass breakage)		
12	11901	XXX730246THB901XXX	PV2	821.50	8.59	PV module output current abnormal (shade/glass breakage/hidden crack)		
13			PV3	-	-	PV string open circuit (PV string breakage/PV string configured by mistake)		
14			PV4	811.70	8.83	PV module output current abnormal (shade/glass breakage/hidden crack)		
15			PV5	819.70	8.52	PV module output current abnormal (shade/glass breakage/hidden crack)		
16			PV7	813.10	8.79	PV module output current abnormal (shade/glass breakage/hidden crack)		
17	11601	XX730246THB9020XXX	PV2	807.50	8.72	PV module output current abnormal (shade/glass breakage/hidden crack)		
18			PV3	809.20	8.86	PV module output current abnormal (shade/glass breakage/hidden crack)		
19	12101	XX730246THB901XXX	PV8	-	-	PV string open circuit (PV string breakage/PV string configured by mistake)		
20	12002	XX730246THB901XXX	PV2	782.00	8.65	PV string voltage abnormal (diode short circuit/PV module invalid/PV module quantity incorrect)		
21			PV7	791.50	8.70	PV string voltage abnormal (diode short circuit/PV module invalid/PV module quantity incorrect)		
22	12102	XX730246TJB900XXX	PV1	820.30	8.78	PV module output current abnormal (shade/glass breakage/hidden crack)		

3. Following advise

NO.	Description	Following advise
1	PV string open circuit (PV string breakage/PV string configured by mistake)	Step 1: Check if the strings are connected correctly, if connections are loose, or not connected. Step 2: If the strings are connected to inverter, then switch off the inverter and pull off the connector between strings and inverter; then measure Voc of the strings with a multimeter and check whether the Voc is within correct parameters. Step 3: If the Voc is within correct parameters, then check whether the connector between string and inverter is broken; if everything is ok, then check if there is a broken circuit inside of inverter. Step 4: If the Voc is abnormal, then check if there is a broken circuit in strings.
2	PV module output current abnormal (shade/glass breakage/hidden crack)	Step 1: Observe the PV string for shade. If there is shade, eliminate the shade and measure again. Step 2: If there is no shadow on panel, check if there are foreign matters or dirt on the surface of the panel; if yes, then measure again after removing the foreign matters. Step 3: If there is no shadow on the surface of panel, please check if there is broken glass; if yes, please measure again after replacing with same model of PV module. Step 4: If no PV module has a broken glass panel, check whether the PV string has been cleaned. If not, clean the PV string and then measure again after the PV module surface is dry. Step 5: If the PV string has been cleaned, scan the PV string using an infrared thermal imager to locate the abnormal PV module. Step 6: If there is no fault, please identify the module with abnormal current by IV tester.
3	Current mismatch in the PV string (shade/dust/PV module current inconsistent)	Step 1: Please check if the scanning is done at a sunny day, current mismatch may occur when the irradiance changes dramatically. Step 2: Check if there is shadow; if yes, please measure again after removing the shadow. Step 3: If no, please check string was cleaned. Step 4: If the PV string has not been cleaned, clean the PV string and then measure again after the PV module surface is dry. Step 5: If string was cleaned, please check if there are panels with low Isc or from other power class by IV testing of each panel.
4	Abnormal curve near MPP in the PV string (hotspot/hidden crack/glass breakage)	Step 1: Please check if the scan was done in a sunny day, the rapid change of irradiance may induce IV curve become abnormal. Step 2: Please check if the string was cleaned. Step 3: If the PV string has not been cleaned, clean the PV string and then measure again after the PV module surface is dry. Step 4: Scan the PV string using an infrared thermal imager to locate the abnormal PV module. Step 5: If no abnormal temperature was found, please use IV test to identify the module with abnormal output current.
5	PV string voltage abnormal (diode short circuit/PV module invalid/PV module quantity incorrect)	Step 1: Check whether the number of PV modules connected to the PV string is correct. Step 2: Observe whether there are traces of burning at the interconnection strip, backsheet, and wiring box. If so, replace the PV module with the same model. Step 3: If none of the above exists, please use IR camera to check if there is short circuited diode or broken ribbon for interconnection. Step 4: If there is no abnormal found on the module with IR camera, please use voltage meter to check the voltage of the strings (from same MPPT), to see if it is too low. And if yes, please measure the temperature of panels in string to check whether there is abnormal temperature distribution.



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