



Test Report
April 21, 2017

PAN File Shinsung E&G Co., Ltd.
60 cell Model SS-BM270NE



Issued by:

Issued to:

Inmo Sung
TUV-SUD Korea

Renewable Energy
Test Center (RETC)
46457 Landing Parkway
Fremont, CA 94538

Reviewed by:
Cherif Kedir
EVP Engineering & Ops

Reviewed by:
Alelie Funcell
President and CEO



PAN File
Performance Measurements, Light Induced Degradation, and PVSyst PAN File
Testing per IEC 61853-1 and IEC 61853-2

Test Scope PAN File Creation, AOI Measurement

Tested Product Configuration

Product	Manufacturer	Description	Qty	Model Number	Remark
Module	Shinsung E&G Co., Ltd.	60 Mono-Si Cell Module	4	SS-BM270NE	Engineering

PAN File Generation: SS-BM270NE, SS-BM270NE-HV
PAN File Extrapolation: SS-BM260NE, SS-BM265NE, SS-BM275NE, SS-BM280NE,
 SS-BM260NE-HV, SS-BM265NE-HV, SS-BM275NE-HV, SS-BM280NE-HV

Client	Company	TÜV SÜD Korea 12F, "KLI63" Bldg., #60 Yoido-Dong, Youngdeung
	Contact Person	Inmo Sung In-Mo.Sung@tuv-sud.kr

Test Site	Company	Renewable Energy Test Center (RETC) 46457 Landing Parkway, Fremont CA 94538
	Contact Person	Ms. Zennia Villanueva Sr. QA Director O: 510-226-1635 – F: 510-952-4351 Email: zenniav@retc-ca.com

Tests Conducted by:	Manny Siason Sr. Director of Engineering and Operations	
Reviewed by:	Cherif Kedir EVP for Engineering and Operations	
Test Date (Start/End):	02/09/2017 – 04/17/2017	
Submission Date:	Report: 4/21/2017	
Version:	V1.0	

This report shall not be reproduced except in full. The results were obtained by following standard laboratory procedures and per the international standards listed in the test plan. The results in this report are only representative of the samples as received by RETC.



List of Symbols and Abbreviations

EL	Electroluminescence
IEC	International Electrotechnical Commission
N/A	Not Applicable
Pmax	Maximum Power
PV	Photovoltaic (Solar)
STC	Standard Test Conditions, AM1.5, 25°C, 1000W/m ²
%RH	% Relative Humidity
IRR	Irradiance (W/m ²)
LTC	Low Temperature Conditions, AM1.5, 15°C, 500W/m ²
LIC	Low Irradiance Conditions, AM1.5, 25°C, 200W/m ²
HTC	High Temperature Conditions, AM1.5, 75°C, 1000W/m ²

References

<u>IEC 61215 2005 2nd Ed</u>	Crystalline Silicon Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval
<u>IEC 60904-1 2006 2nd Ed</u>	Photovoltaic Devices Part 1: Measurement of Photovoltaic Current-Voltage Characteristics
<u>IEC 60904-2 2007 2nd Ed</u>	Photovoltaic Devices – Part 2: Requirements for Reference Solar Devices
<u>IEC 60410 1973 1st Ed</u>	Sampling Plans and Procedures for Inspection by Attributes
<u>IEC 61853-1 1st Ed</u>	Photovoltaic (PV) module performance testing and energy rating – Part 1: Irradiance and temperature performance measurements and power rating



Table of Contents

COVER PAGE	1
LIST OF SYMBOLS AND ABBREVIATIONS	3
REFERENCES	3
TABLE OF CONTENTS	4
1 TEST FLOW	4
2 SAMPLE ALLOCATION	6
3 TEST RESULTS	7
3.1 VISUAL INSPECTION.....	7
Visual Inspection – continued	8
3.1.1 Visual Inspection – continued	9
3.2 ELECTROLUMINESCENCE.....	10
3.3 MEASUREMENT OF TEMPERATURE COEFFICIENTS	12
3.4 MAXIMUM POWER DETERMINATION (STC CONDITION)	14
3.5 MAXIMUM POWER DEGRADATION (% DEGRADATION RELATIVE TO INITIAL MEASUREMENTS).....	14
3.6 PERFORMANCE AT MULTI-IRRADIANCE, 25°C	15
3.7 PERFORMANCE AT MULTI-IRRADIANCE, 15°C	16
3.8 PERFORMANCE AT MULTI-IRRADIANCES, 50°C.....	17
3.9 PERFORMANCE AT MULTI-IRRADIANCES, 75°C.....	18
3.10 PERFORMANCE AT LTC, LIC, HTC	19
3.11 INCIDENT ANGLE MODIFIER	20
3.11.1 Incident Angle Modifier Measured Values	20
3.11.2 IAM Polynomial Regression Variables	21
3.11.3 IAM Polynomial Regression Variables Definitions.....	21
3.12 PAN FILE CREATION (V _{sys} = 1000V).....	22
3.12.1 SS-BM270NE	22
3.12.2 SS-BM260NE	23
3.12.3 SS-BM365NE	24
3.12.4 SS-BM275NE	25
3.12.5 SS-BM280NE	26
3.13 PAN FILE CREATION (V _{sys} = 1500V).....	27
3.13.1 SS-BM270NE-HV	27
3.13.2 SS-BM260NE-HV	28
3.13.3 SS-BM265NE-HV	29
3.13.4 SS-BM275NE-HV	30
3.13.5 SS-BM280NE-HV	31
ANNEX 1: LIST OF MEASUREMENT EQUIPMENT	32
ANNEX 2: STATEMENT OF THE ESTIMATED UNCERTAINTY OF THE TEST RESULTS	33



1 Test Flow

Standard	Section	Station	A	B	C	D
IEC 61215		Electroluminescence	✓	✓	✓	✓
IEC 61215	10.1	Visual Inspection	✓	✓	✓	✓
IEC 61215	10.2	Maximum Power Determination	✓	✓	✓	✓
IEC 61853		LID 45kWhr - Light Induced Degradation		✓	✓	✓
IEC 61215	10.2	Maximum Power Determination	✓	✓	✓	✓
IEC 61853		LID 5kWhr - Light Induced Degradation		✓	✓	✓
IEC 61215	10.2	Maximum Power Determination	✓	✓	✓	✓
IEC 61215	10.4	Measurement of Temperature Coefficients		✓		
IEC 61853		15C Maximum Power Determination @ 0100 W/m2		✓	✓	✓
IEC 61853		15C Maximum Power Determination @ 0200 W/m2		✓	✓	✓
IEC 61853		15C Maximum Power Determination @ 0400 W/m2		✓	✓	✓
IEC 61853	7.6	15C Maximum Power Determination @ 0500 W/m2 (LTC)		✓	✓	✓
IEC 61853		15C Maximum Power Determination @ 0600 W/m2		✓	✓	✓
IEC 61853		15C Maximum Power Determination @ 0800 W/m2		✓	✓	✓
IEC 61853		15C Maximum Power Determination @ 1000 W/m2		✓	✓	✓
IEC 61853		25C Maximum Power Determination @ 0100 W/m2		✓	✓	✓
IEC 61853	7.4	25C Maximum Power Determination @ 0200 W/m2 (LIC)		✓	✓	✓
IEC 61853		25C Maximum Power Determination @ 0400 W/m2		✓	✓	✓
IEC 61853		25C Maximum Power Determination @ 0600 W/m2		✓	✓	✓
IEC 61853		25C Maximum Power Determination @ 0800 W/m2		✓	✓	✓
IEC 61853		25C Maximum Power Determination @ 1000 W/m2		✓	✓	✓
IEC 61853		25C Maximum Power Determination @ 1100 W/m2		✓	✓	✓
IEC 61853		50C Maximum Power Determination @ 0600 W/m2		✓	✓	✓
IEC 61853		50C Maximum Power Determination @ 0800 W/m2		✓	✓	✓
IEC 61853		50C Maximum Power Determination @ 1000 W/m2		✓	✓	✓
IEC 61853		50C Maximum Power Determination @ 1100 W/m2		✓	✓	✓
IEC 61853		75C Maximum Power Determination @ 0600 W/m2		✓	✓	✓
IEC 61853		75C Maximum Power Determination @ 0800 W/m2		✓	✓	✓
IEC 61853		75C Maximum Power Determination @ 1100 W/m2		✓	✓	✓
IEC 61853		AOI Measurement			✓	
IEC 61853		IAM Computation			✓	
IEC 61853		PAN File Creation		✓		

✓: Test sequence completed



2 Sample Allocation

RETC ID	Module ID	Module Number	Test
TVK-010-A	BP2604EM1WB6CN1170200124	SS-BM270NE	Control
TVK-010-B	BP2604EM1WB6CN1170200122	SS-BM270NE	Multi-Irr, Temp, Tempco
TVK-010-C	BP2604EM1WB6CN1170200121	SS-BM270NE	Multi-Irr, Temp, AOI
TVK-010-D	BP2604EM1WB6CN1170200123	SS-BM270NE	Multi-Irr, Temp

3 Test Results

3.1 Visual Inspection

Note: Representative Photos

INITIAL [T0]: No major visual defects observed as per IEC 61215

MODULE LABEL



SHINSUNG SOLAR ENERGY CO.,LTD.
Office Address : 8, Daewangpangyo-ro 395, Bundang-gu,
Seongnam-si, Gyeonggi-do, Korea
A/S Tel : 82 31 7889 500 Fax : 82 31 7889 510
E-mail: solar@shinsung.co.kr
www.shinsung.co.kr

MADE IN KOREA

MODEL : SS – BM270NE

Facility Name : Photovoltaic module

STC : 1000W/m ² , AM1.5, 25°C		
NOMINAL MAX. POWER (Pmax)	270	W
PRODUCTION POWER TOLERANCE	+3%	
OPEN CIRCUIT VOLTAGE (Voc)	38.20	V
SHORT CIRCUIT CURRENT (Isc)	9.22	A
MAXIMUM POWER VOLTAGE (Vmp)	31.00	V
MAXIMUM POWER CURRENT (Imp)	8.71	A
MAXIMUM SYSTEM VOLTAGE (IEC)		VDC
MAXIMUM SYSTEM VOLTAGE (UL)	1500	VDC
MAXIMUM SERIES FUSE RATING	15	A
DIMENSION (W x L x T mm)	992*1650*40	
WEIGHT	18.8	Kg
FIRE RESISTANCE RATING (IEC 61730)		
FIRE PERFORMANCE (UL1703)	Type 1	
MAX. TESTED LOAD (IEC)		Pa
(UL)	40	lbs/ft ²

APPLICATION CLASS(IEC)

System Fire Class Rating: See Installation Instructions for Installation Requirements to Achieve a Specified System Fire Class Rating with this Product. Maximum series overcurrent protective device, where required.

FIELD WIRING
For field connections, use minimum 12 AWG (US, Canada), 4 mm² (EU, Asia) copper wires insulated for a minimum of 90°C, rated for wet conditions and resistant to ultra violet radiation where exposed.
Qualified, IEC 61215 Safety tested, IEC 61730



<p>CAUTION</p>  <p>The electric shock hazard increase as circuits operating in excess of 45 volts, nominal, maximum system voltage for DC or 45 volts for AC circuits</p>	KS규격번호 : KS C 8561		설비명 : 결정질태양광모듈	
	KS규격명 : 결정질 실리콘 태양광발전 모듈(성능)			
	인증기관 : 한국에너지공단		타입	
	모델코드 :		조합 -	
	Certification	No.	Date.	
	KS	PV0116012		

Manufacturer Factory Address : 108-73, Hansam-ro, Daeso-myeon, Eumseong-gun, Chungcheongbuk-do, 369-823, Korea
Tel : 82-43-8800-565
Manufactured Date : 2017.02.01

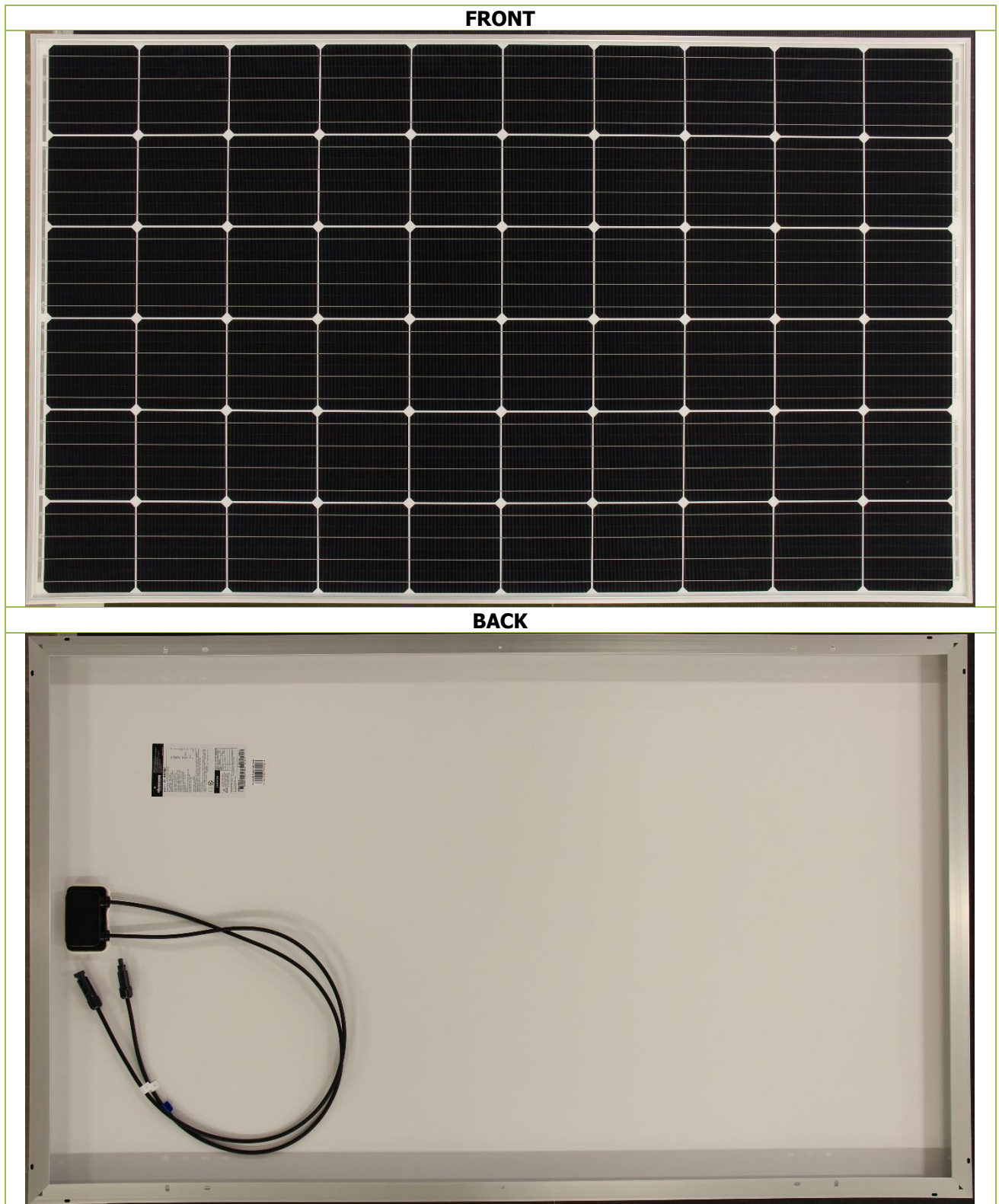
MODEL SERIAL No.

SS – BM270NE – 170200124

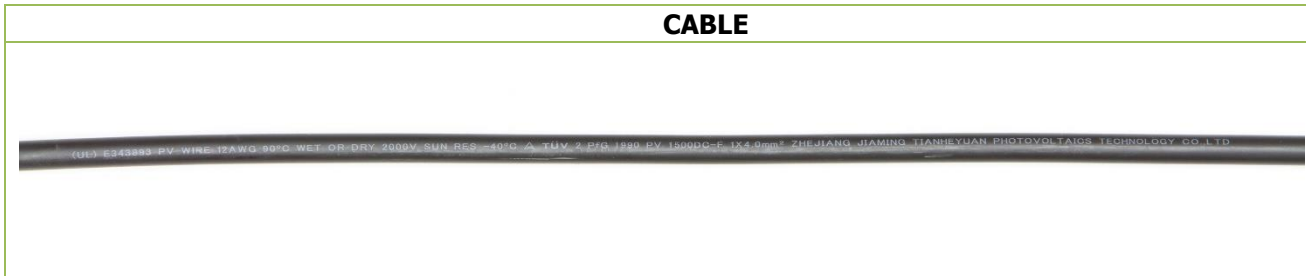
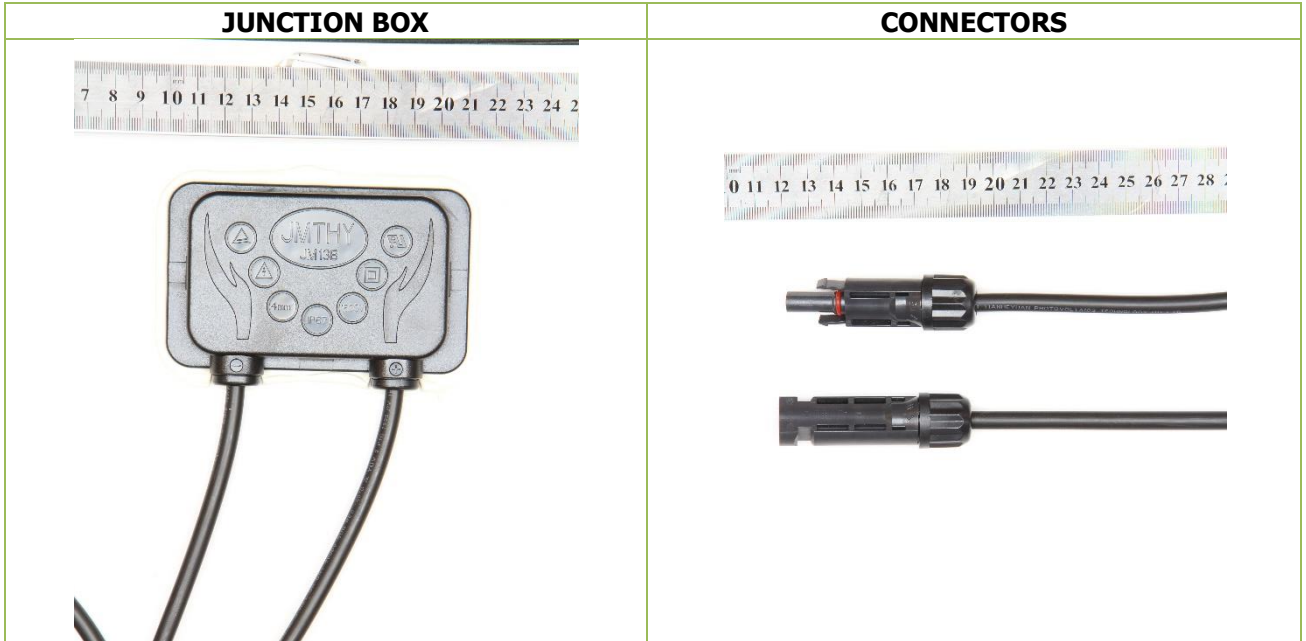


5BP260CA BP2604EM1WB6CN1 1702 00124

Visual Inspection – continued

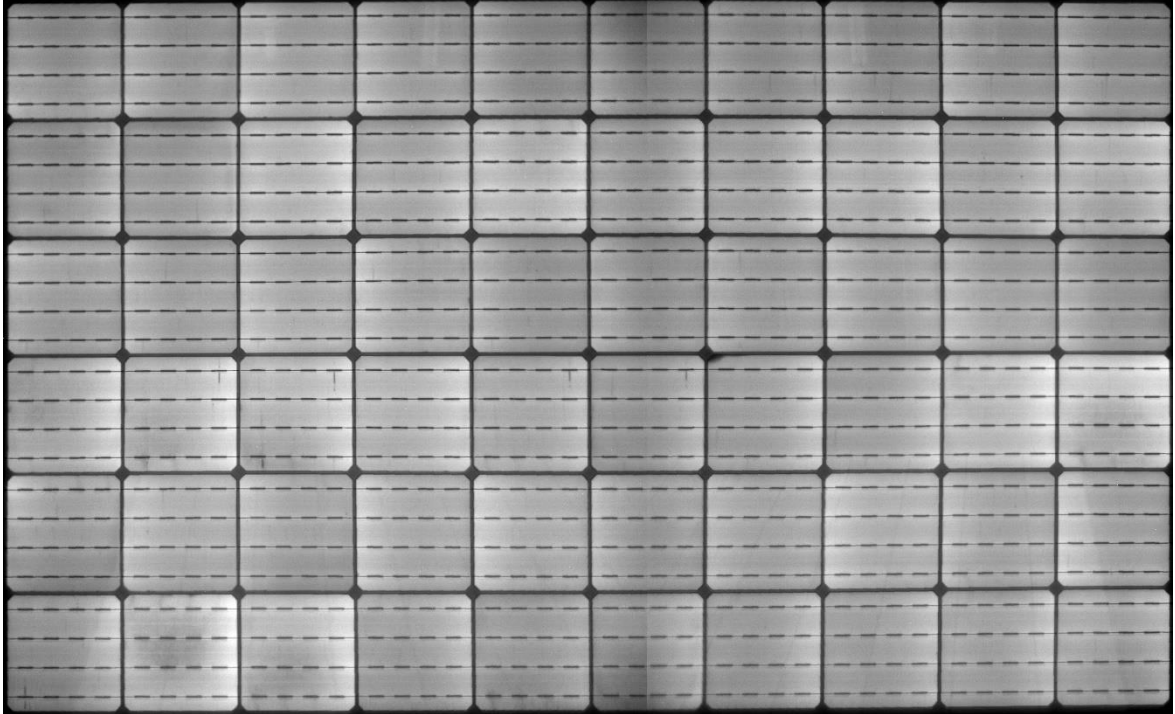


3.1.1 Visual Inspection – continued



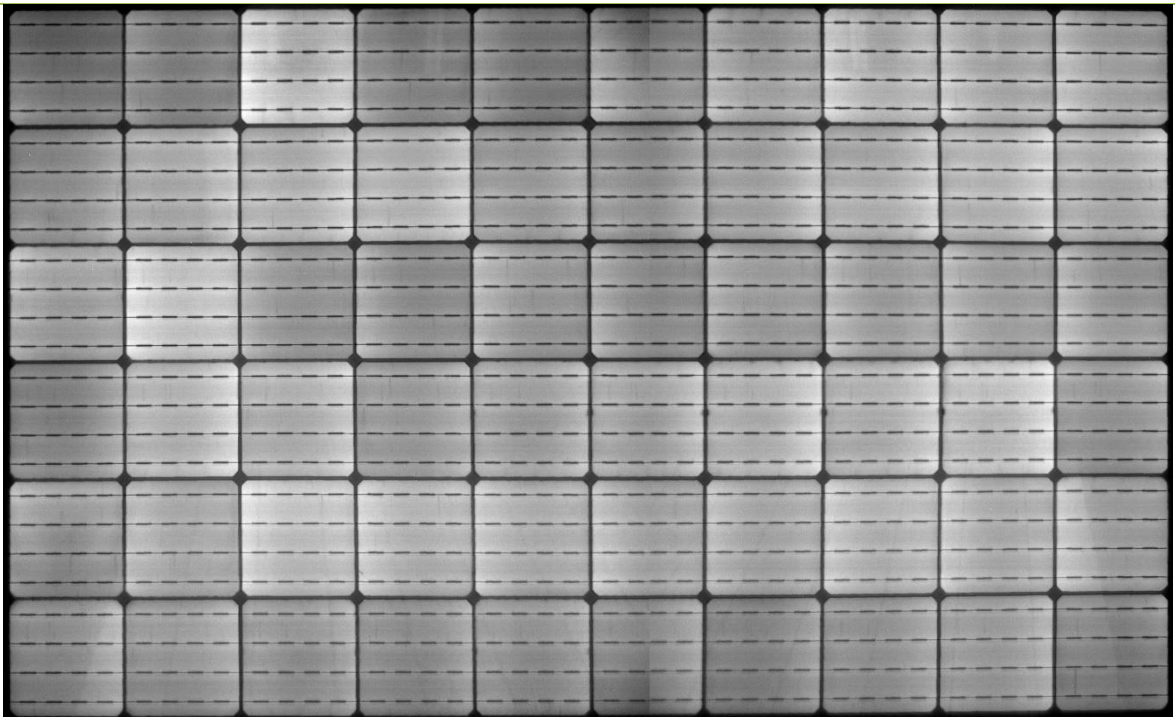
3.2 Electroluminescence

TVK-010-A – Initial



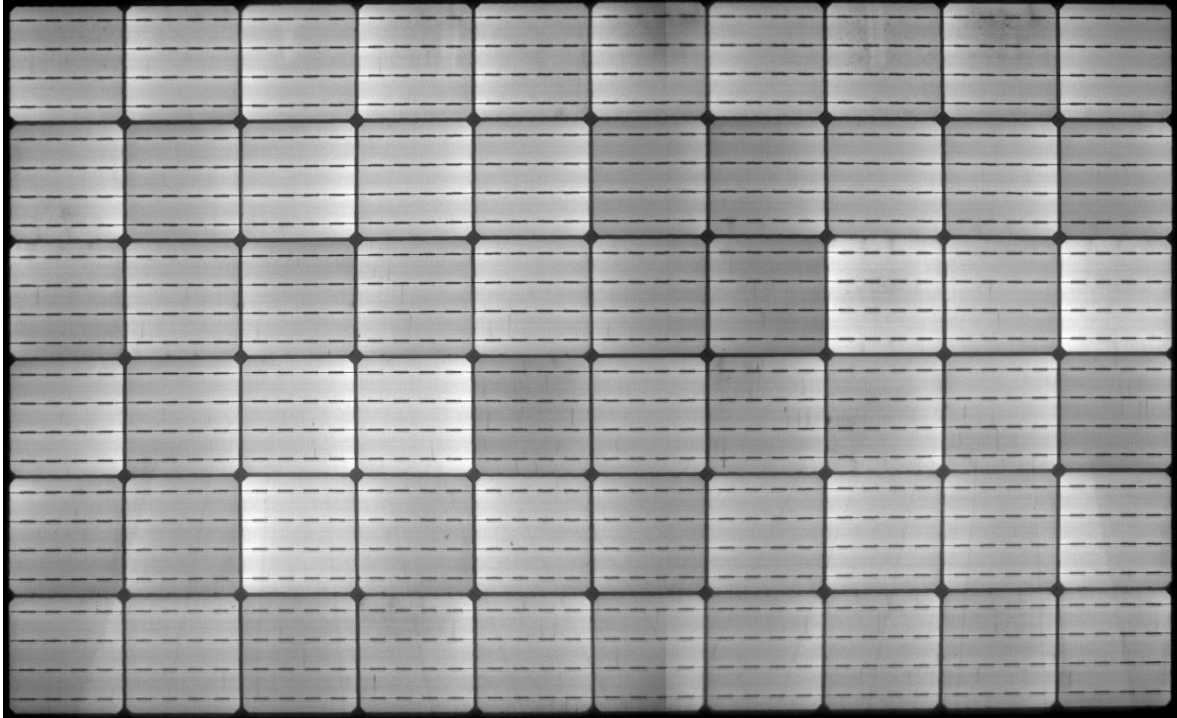
Broken Finger: No major issues observed	Cell Darkening: No major issues observed
Cracks/Microcracks: No major issues observed	Failing Solder Joints: No major issues observed

TVK-010-B – Initial



Broken Finger: No major issues observed	Cell Darkening: No major issues observed
Cracks/Microcracks: No major issues observed	Failing Solder Joints: No major issues observed

TVK-010-C – Initial



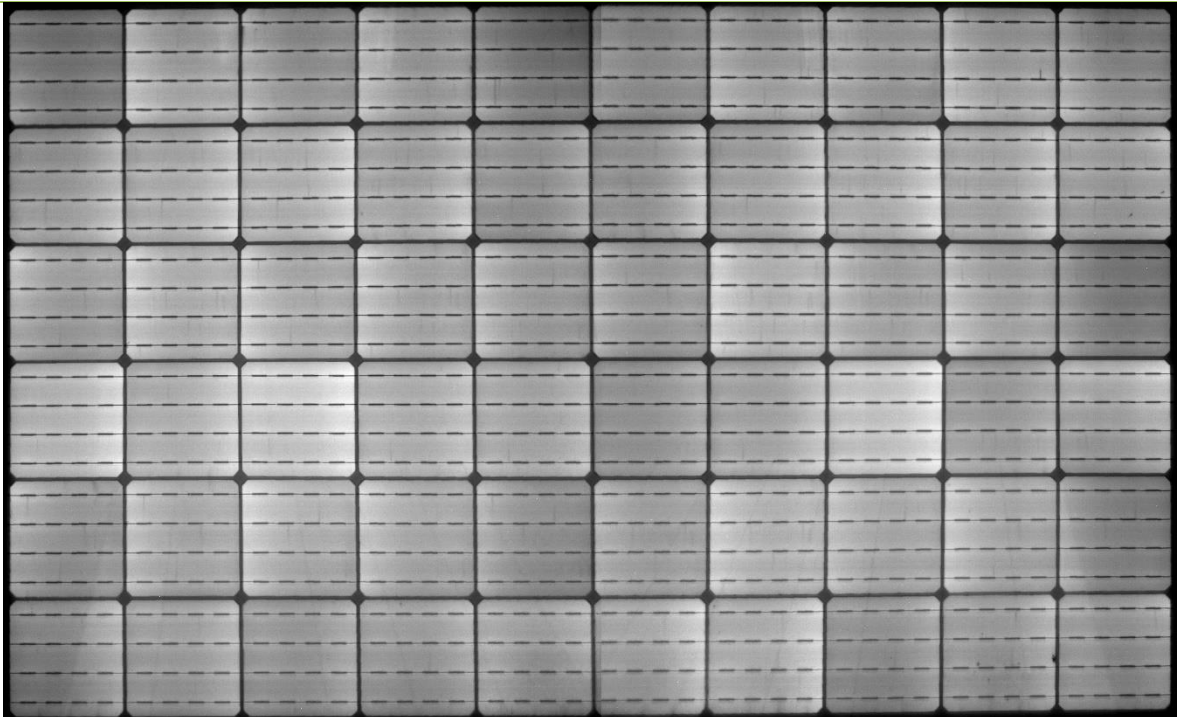
Broken Finger: No major issues observed

Cell Darkening: No major issues observed

Cracks/Microcracks: No major issues observed

Failing Solder Joints: No major issues observed

TVK-010-D – Initial



Broken Finger: No major issues observed

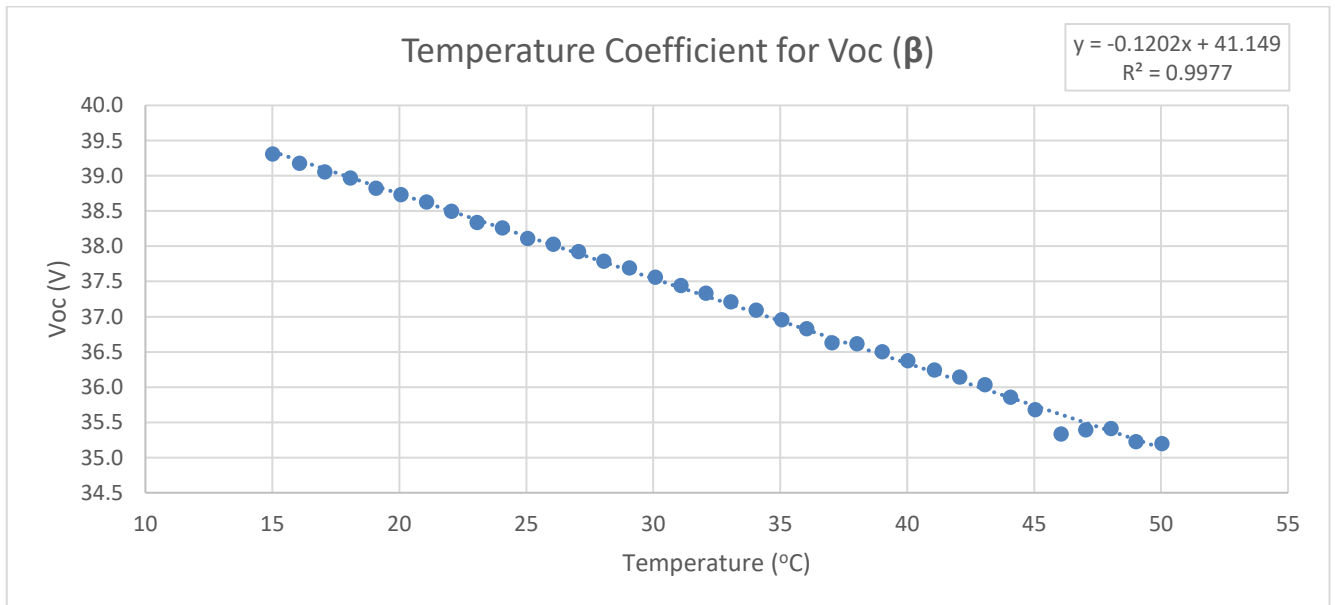
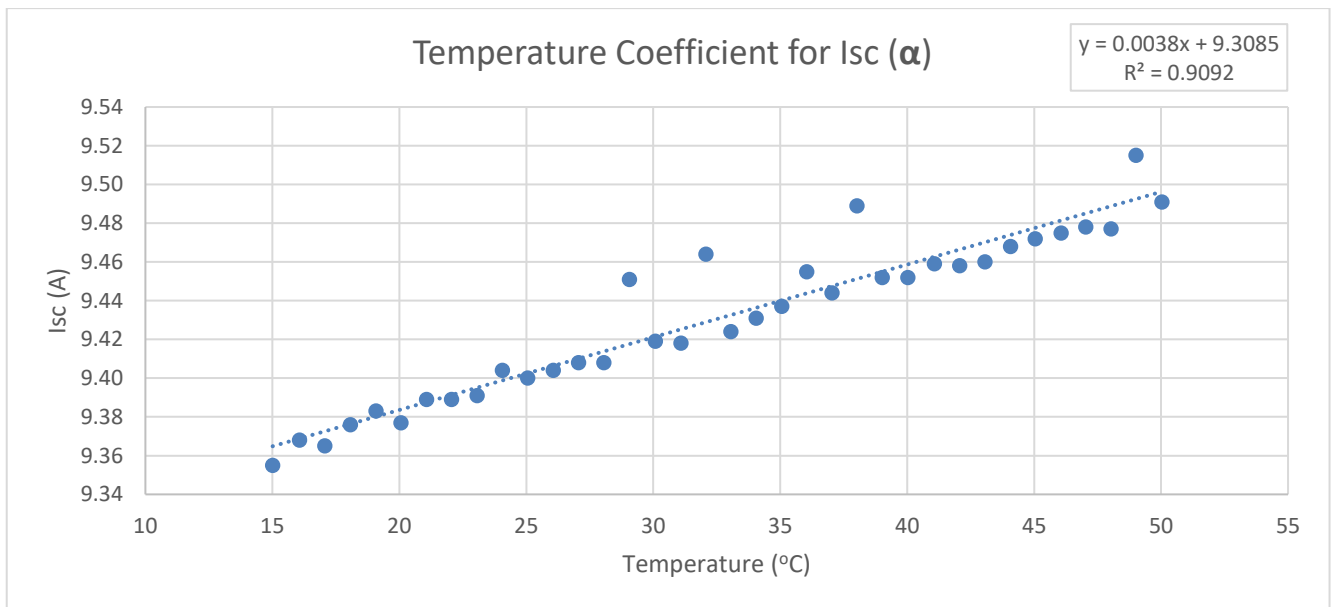
Cell Darkening: No major issues observed

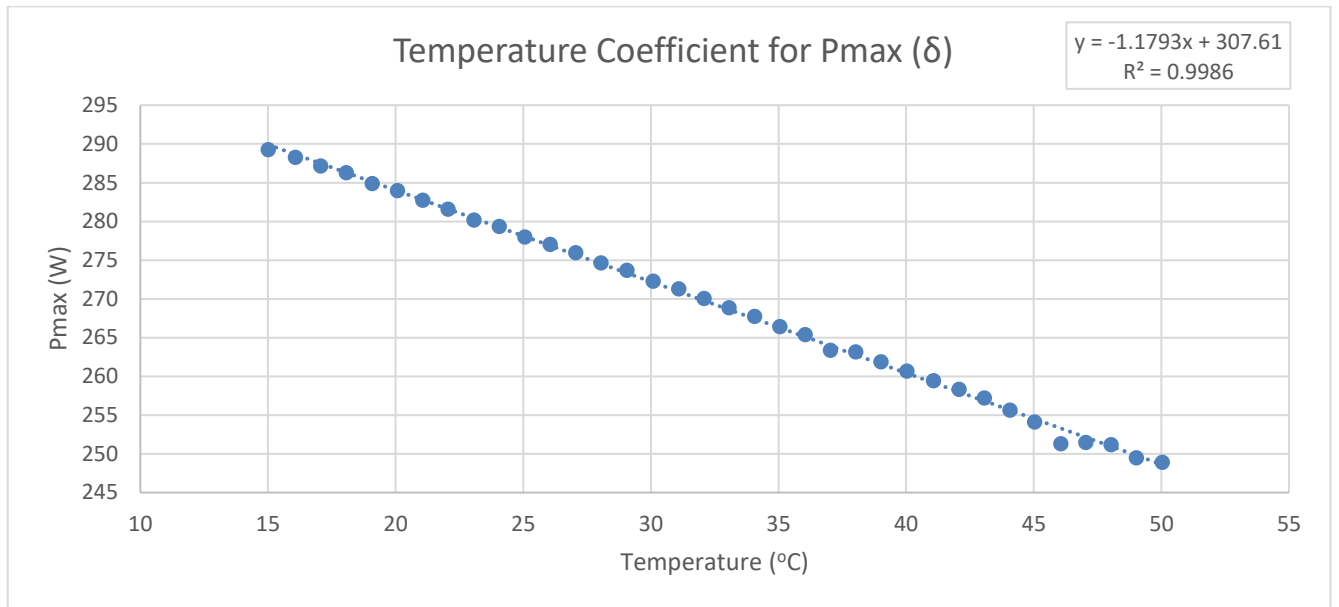
Cracks/Microcracks: No major issues observed

Failing Solder Joints: No major issues observed

3.3 Measurement of Temperature Coefficients

Radiant source		<input checked="" type="checkbox"/> Solar simulator, <input type="checkbox"/> Natural sunlight
Irradiance at which the measurements were made (W/m ²)		1000
Range of module temperature (high/low) (°C) ... :		50.04 / 15.01
Parameter	Sample #	Calculated Value
Current: α (%/°C)	TVK-010-B	0.040
Voltage: β (%/°C)		-0.316
Peak power: δ (%/C)		-0.424





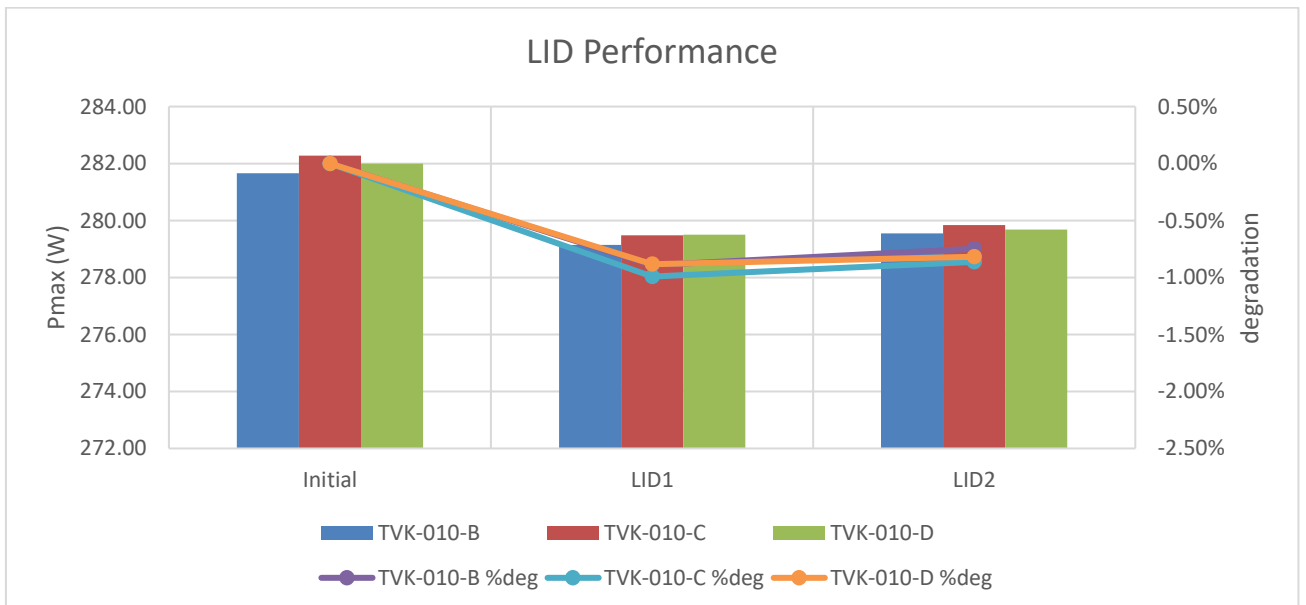
3.4 Maximum Power Determination (STC condition)

Note: Data values are normalized to control (TVK-010-A)

SN	Sequence (Post)	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)
TVK-010-A	Initial	38.454	31.566	9.409	8.977	283.359	78.320
TVK-010-B	Initial	38.346	31.499	9.411	8.942	281.657	78.050
	LID1	38.204	31.227	9.388	8.940	279.145	77.839
	LID2	38.241	31.244	9.378	8.948	279.549	77.958
TVK-010-C	Initial	38.416	31.530	9.406	8.953	282.276	78.120
	LID1	38.289	31.216	9.373	8.954	279.477	77.879
	LID2	38.343	31.272	9.360	8.949	279.837	77.978
TVK-010-D	Initial	38.384	31.516	9.364	8.948	281.995	78.460
	LID1	38.240	31.367	9.330	8.912	279.504	78.350
	LID2	38.246	31.246	9.322	8.951	279.686	78.451

3.5 Maximum Power Degradation (% Degradation relative to Initial Measurements)

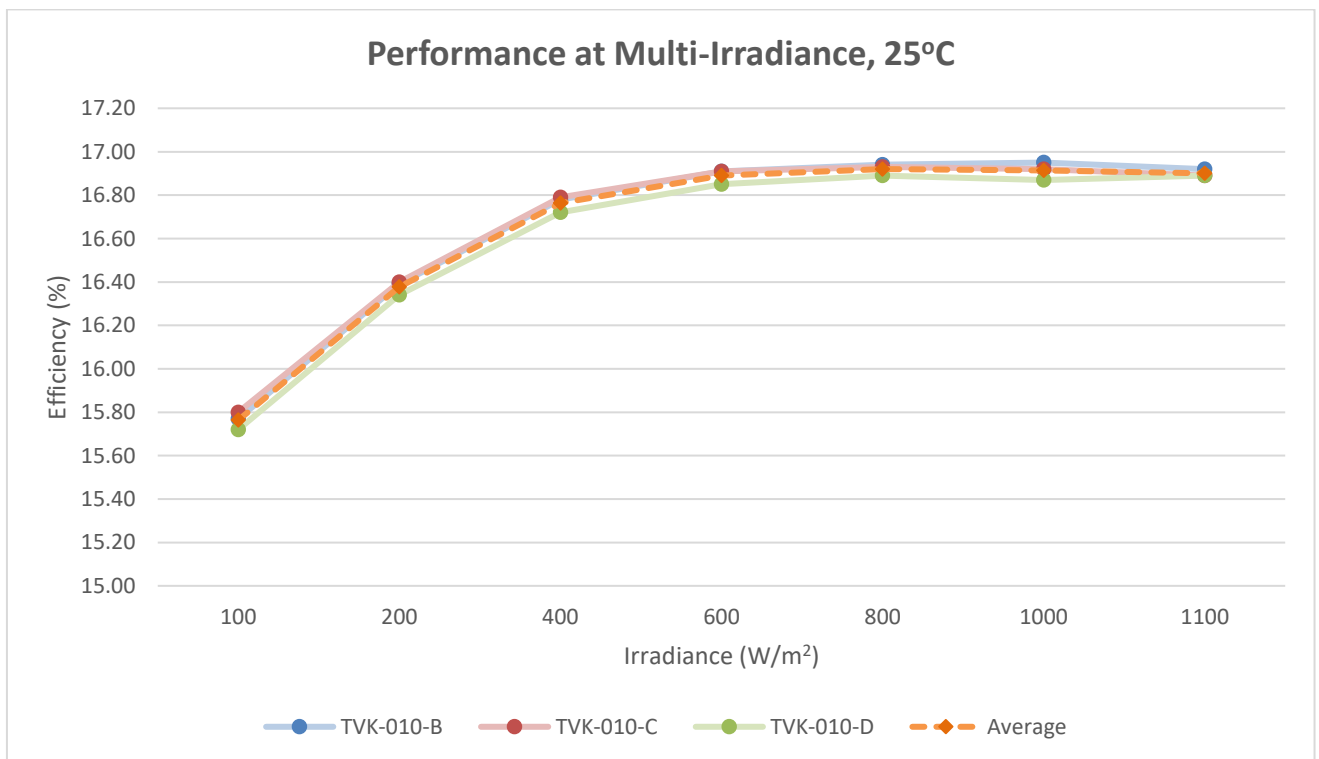
SN	Sequence (Post)	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)
TVK-010-B	LID1	-0.37%	-0.86%	-0.24%	-0.02%	-0.89%	-0.27%
	LID2	-0.27%	-0.81%	-0.35%	0.07%	-0.75%	-0.12%
<i>Difference between LID1 and LID2</i>		<i>0.10%</i>	<i>0.05%</i>	<i>-0.11%</i>	<i>0.09%</i>	<i>0.14%</i>	<i>0.15%</i>
TVK-010-C	LID1	-0.33%	-1.00%	-0.35%	0.01%	-0.99%	-0.31%
	LID2	-0.19%	-0.82%	-0.49%	-0.04%	-0.86%	-0.18%
<i>Difference between LID1 and LID2</i>		<i>0.14%</i>	<i>0.18%</i>	<i>-0.14%</i>	<i>-0.06%</i>	<i>0.13%</i>	<i>0.13%</i>
TVK-010-D	LID1	-0.38%	-0.47%	-0.36%	-0.40%	-0.88%	-0.14%
	LID2	-0.36%	-0.86%	-0.45%	0.03%	-0.82%	-0.01%
<i>Difference between LID1 and LID2</i>		<i>0.02%</i>	<i>-0.38%</i>	<i>-0.09%</i>	<i>0.44%</i>	<i>0.06%</i>	<i>0.13%</i>



Note: average %degradation after LID2: -0.81%

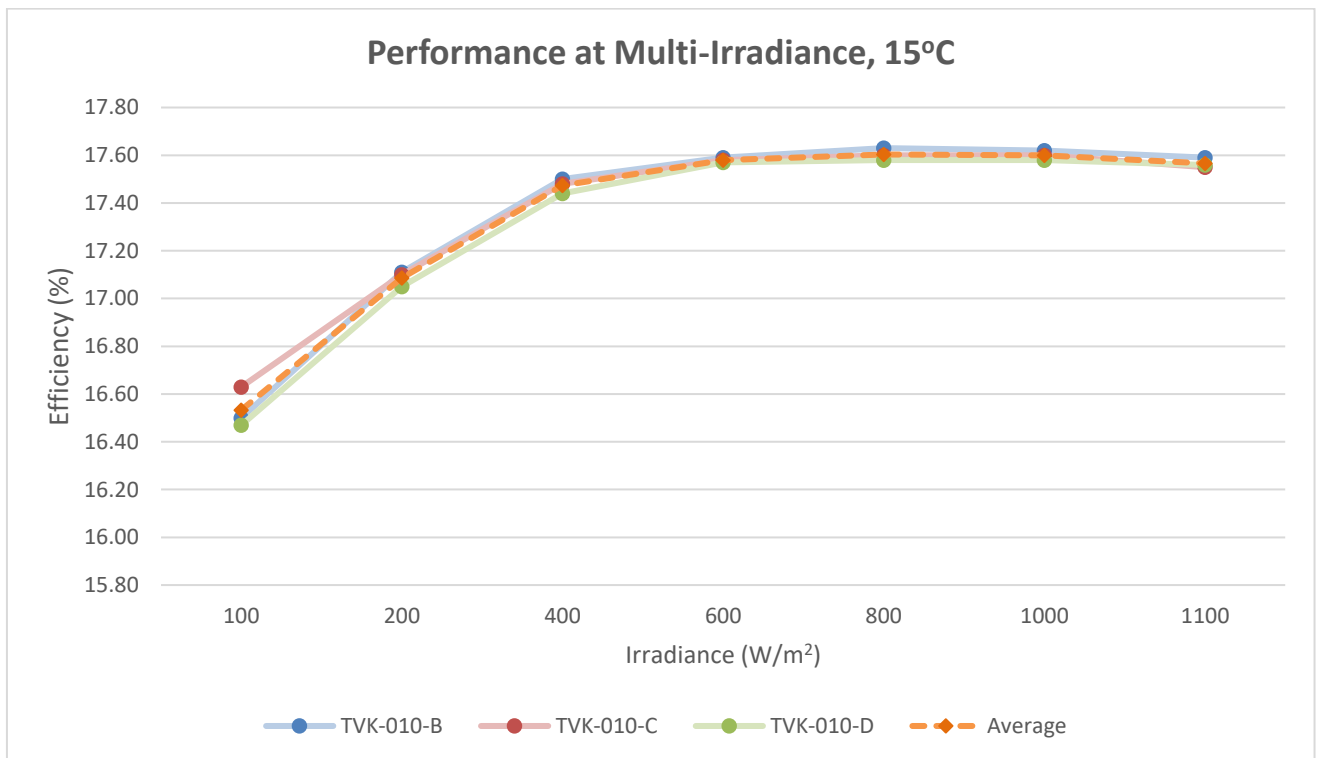
3.6 Performance at Multi-Irradiance, 25°C

SN	IRR (W/m ²)	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)	Eff (%)
TVK-010-B	100	34.208	29.067	0.934	0.886	25.743	80.610	15.770
	200	35.375	30.068	1.879	1.780	53.523	80.530	16.390
	400	36.558	30.804	3.736	3.558	109.608	80.240	16.780
	600	37.256	31.034	5.597	5.339	165.699	79.470	16.910
	800	37.736	31.235	7.470	7.083	221.227	78.480	16.940
	1000	38.128	31.220	9.362	8.864	276.736	77.530	16.950
	1100	38.287	31.183	10.341	9.744	303.855	76.740	16.920
TVK-010-C	100	34.314	29.337	0.931	0.879	25.797	80.790	15.800
	200	35.474	30.122	1.863	1.778	53.542	81.030	16.400
	400	36.652	30.938	3.722	3.544	109.650	80.370	16.790
	600	37.348	31.166	5.571	5.316	165.662	79.630	16.910
	800	37.837	31.234	7.419	7.078	221.087	78.760	16.930
	1000	38.206	31.197	9.294	8.855	276.254	77.800	16.920
	1100	38.378	31.147	10.235	9.741	303.400	77.240	16.890
TVK-010-D	100	34.223	29.187	0.926	0.880	25.672	80.990	15.720
	200	35.398	30.220	1.861	1.766	53.360	80.980	16.340
	400	36.561	30.790	3.710	3.547	109.207	80.510	16.720
	600	37.250	31.161	5.534	5.297	165.073	80.070	16.850
	800	37.742	31.216	7.397	7.067	220.614	79.020	16.890
	1000	38.037	31.131	9.266	8.847	275.416	78.150	16.870
	1100	38.302	31.155	10.195	9.736	303.329	77.680	16.890



3.7 Performance at Multi-Irradiance, 15°C

SN	IRR	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)	Eff (%)
TVK-010-B	100	35.502	30.583	0.930	0.881	26.938	81.560	16.500
	200	36.617	31.368	1.865	1.781	55.871	81.820	17.110
	400	37.761	32.058	3.726	3.566	114.324	81.250	17.500
	600	38.448	32.322	5.565	5.330	172.285	80.520	17.590
	800	38.931	32.429	7.464	7.103	230.348	79.280	17.630
	1000	39.297	32.412	9.319	8.878	287.767	78.580	17.620
	1100	39.451	32.395	10.276	9.750	315.851	77.910	17.590
TVK-010-C	100	35.626	30.728	0.925	0.884	27.156	82.420	16.630
	200	36.742	31.596	1.853	1.768	55.852	82.040	17.100
	400	37.871	32.212	3.704	3.544	114.170	81.390	17.480
	600	38.537	32.443	5.542	5.309	172.248	80.650	17.580
	800	39.015	32.508	7.389	7.071	229.847	79.730	17.600
	1000	39.379	32.482	9.281	8.847	287.352	78.620	17.600
	1100	39.535	32.462	10.172	9.708	315.149	78.370	17.550
TVK-010-D	100	35.537	30.581	0.922	0.879	26.892	82.090	16.470
	200	36.659	31.543	1.850	1.766	55.689	82.110	17.050
	400	37.791	32.229	3.692	3.535	113.926	81.660	17.440
	600	38.456	32.478	5.519	5.300	172.141	81.110	17.570
	800	38.933	32.571	7.361	7.051	229.662	80.130	17.580
	1000	39.300	32.535	9.269	8.824	287.099	78.810	17.580
	1100	39.464	32.496	10.143	9.709	315.486	78.820	17.560



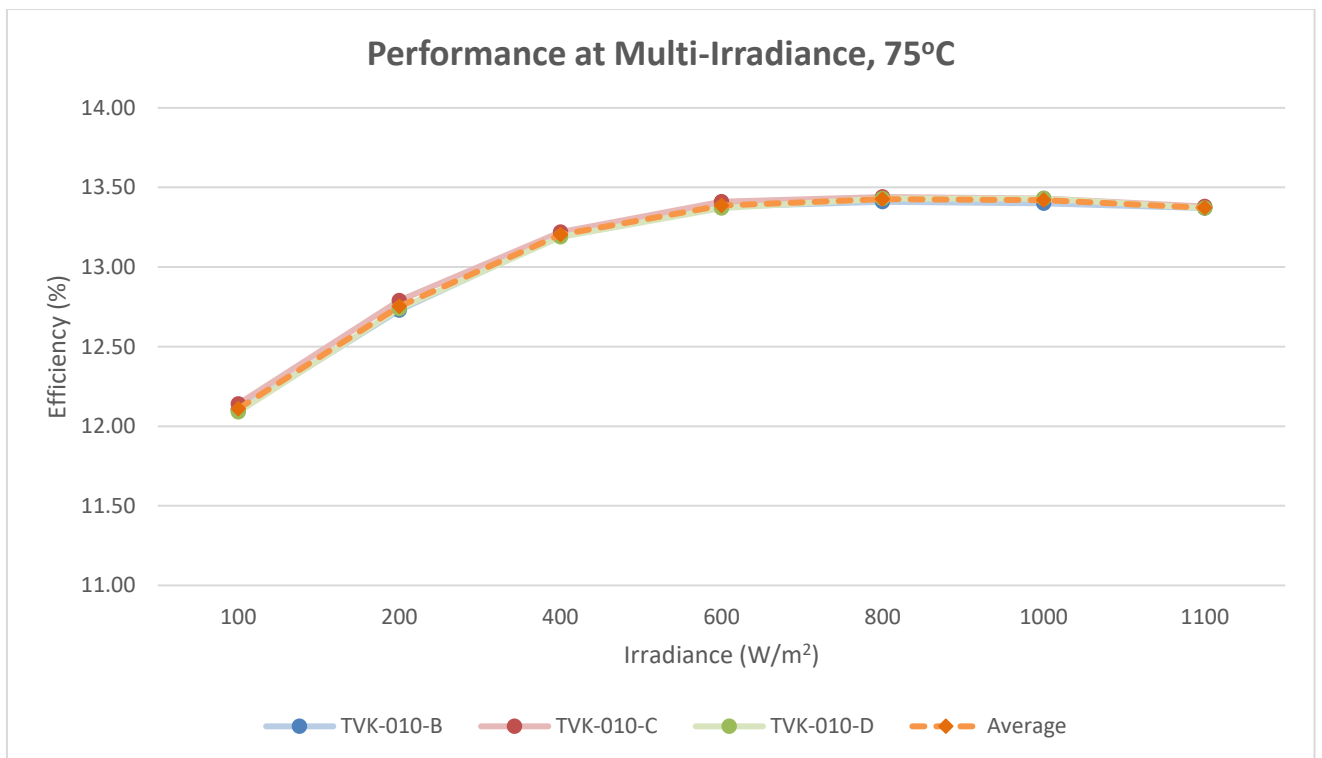
3.8 Performance at Multi-Irradiances, 50°C

SN	IRR	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)	Eff (%)
TVK-010-B	100	30.895	25.855	0.944	0.881	22.767	78.030	13.940
	200	32.167	26.795	1.911	1.777	47.606	77.460	14.580
	400	33.456	27.604	3.776	3.546	97.891	77.490	14.990
	600	34.218	27.809	5.656	5.335	148.368	76.660	15.140
	800	34.766	27.995	7.533	7.073	198.010	75.600	15.160
	1000	35.172	27.943	9.439	8.863	247.646	74.590	15.170
	1100	35.355	27.867	10.421	9.755	271.855	73.790	15.140
TVK-010-C	100	31.040	26.004	0.942	0.884	22.995	78.630	14.080
	200	32.288	26.825	1.914	1.777	47.660	77.140	14.590
	400	33.568	27.600	3.756	3.547	97.906	77.650	14.990
	600	34.328	27.939	5.623	5.312	148.426	76.900	15.150
	800	34.859	27.939	7.511	7.085	197.948	75.610	15.150
	1000	35.252	28.025	9.397	8.824	247.283	74.650	15.140
	1100	35.449	27.932	10.332	9.714	271.339	74.090	15.110
TVK-010-D	100	30.948	25.856	0.949	0.886	22.905	78.000	14.030
	200	32.200	26.909	1.872	1.768	47.575	78.940	14.570
	400	33.484	27.609	3.744	3.545	97.868	78.070	14.980
	600	34.237	27.970	5.605	5.299	148.203	77.230	15.130
	800	34.772	27.977	7.468	7.069	197.761	76.160	15.140
	1000	35.186	28.072	9.375	8.813	247.402	75.000	15.150
	1100	35.349	27.973	10.332	9.704	271.454	74.330	15.110



3.9 Performance at Multi-Irradiances, 75°C

SN	IRR	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)	Eff (%)
TVK-010-B	100	27.586	22.493	0.960	0.878	19.759	74.630	12.100
	200	28.923	23.572	1.909	1.763	41.560	75.280	12.730
	400	30.368	24.401	3.837	3.532	86.191	73.960	13.200
	600	31.184	24.713	5.762	5.304	131.084	72.950	13.380
	800	31.771	24.827	7.612	7.054	175.123	72.410	13.410
	1000	32.221	24.898	9.566	8.790	218.855	71.010	13.400
	1100	32.420	24.782	10.515	9.690	240.142	70.450	13.370
TVK-010-C	100	27.713	22.519	0.956	0.880	19.816	74.790	12.140
	200	29.094	23.678	2.032	1.764	41.775	70.670	12.790
	400	30.491	24.398	3.801	3.539	86.353	74.520	13.220
	600	31.326	24.860	5.697	5.286	131.405	73.630	13.410
	800	31.895	24.946	7.589	7.036	175.517	72.520	13.440
	1000	32.336	25.034	9.498	8.758	219.245	71.390	13.430
	1100	32.518	24.888	10.432	9.655	240.299	70.840	13.380
TVK-010-D	100	27.615	22.502	0.954	0.877	19.736	74.880	12.090
	200	28.971	23.571	1.926	1.765	41.599	74.550	12.740
	400	30.370	24.404	3.795	3.530	86.140	74.750	13.190
	600	31.199	24.846	5.668	5.273	131.000	74.080	13.370
	800	31.786	24.968	7.565	7.026	175.420	72.950	13.430
	1000	32.235	24.881	9.476	8.811	219.218	71.770	13.430
	1100	32.411	24.920	10.395	9.637	240.162	71.280	13.370





3.10 Performance at LTC, LIC, HTC

SN	Condition	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)	Eff (%)
TVK-010-B	LTC	38.133	32.320	4.669	4.440	143.507	80.610	17.580
	LIC	35.375	30.068	1.879	1.780	53.523	80.530	16.390
	HTC	32.221	24.898	9.566	8.790	218.855	71.010	13.400
TVK-010-C	LTC	38.231	32.297	4.643	4.436	143.280	80.720	17.550
	LIC	35.474	30.122	1.863	1.778	53.542	81.030	16.400
	HTC	32.336	25.034	9.498	8.758	219.245	71.390	13.430
TVK-010-D	LTC	38.158	32.316	4.629	4.425	142.996	80.960	17.520
	LIC	35.398	30.220	1.861	1.766	53.360	80.980	16.340
	HTC	32.235	24.881	9.476	8.811	219.218	71.770	13.430

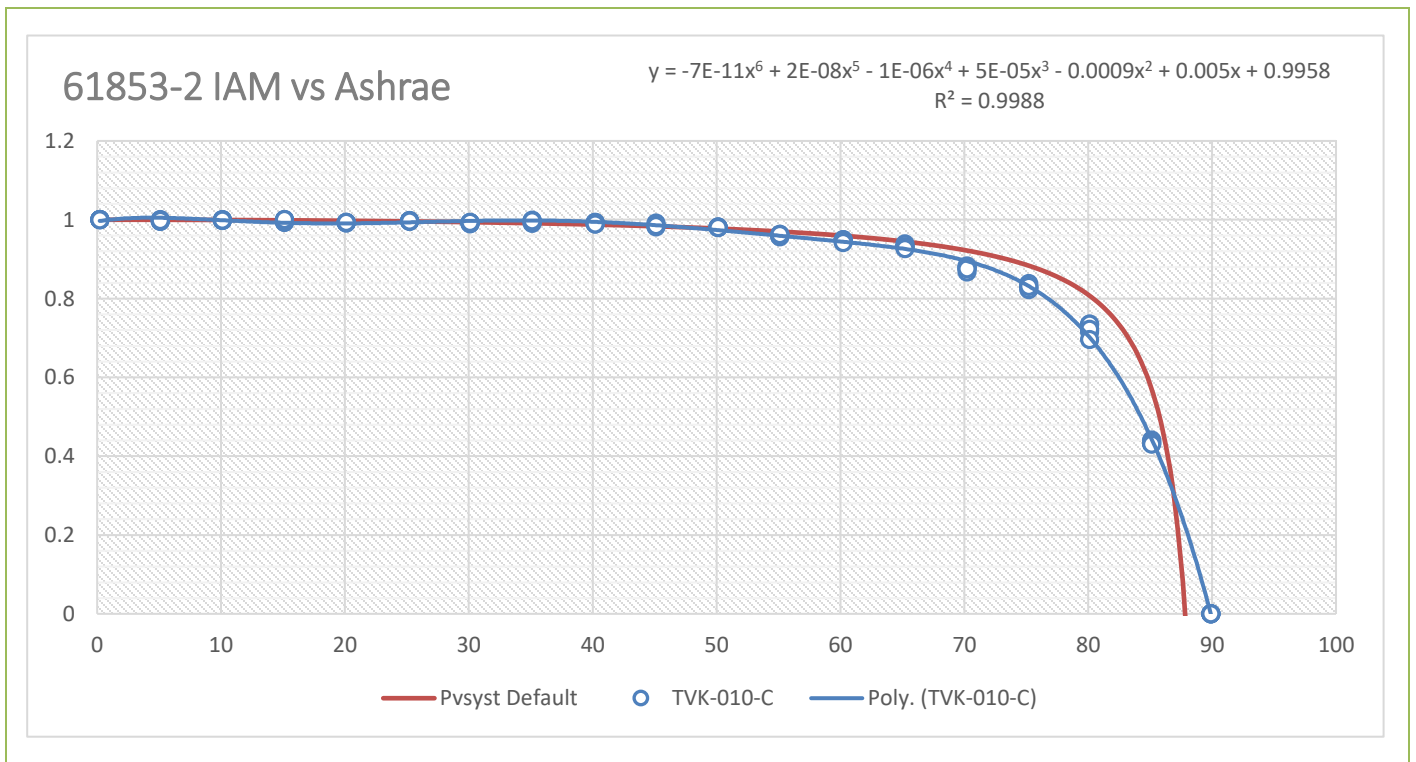
3.11 Incident Angle Modifier
3.11.1 Incident Angle Modifier Measured Values

Measured Coefficients

AOI	Min	Ave	Max
0.0	1.000	1.000	1.000
5.0	0.995	0.998	1.000
10.0	0.998	0.999	1.000
15.0	0.993	0.997	1.000
20.0	0.991	0.992	0.993
25.0	0.996	0.997	0.998
30.0	0.990	0.992	0.993
35.0	0.991	0.995	0.998
40.0	0.989	0.991	0.993
45.0	0.982	0.986	0.991
50.0	0.980	0.981	0.982
55.0	0.956	0.960	0.963
60.0	0.942	0.947	0.949
65.0	0.927	0.932	0.939
70.0	0.867	0.876	0.883
75.0	0.822	0.830	0.838
80.0	0.696	0.721	0.735
85.0	0.430	0.435	0.441
90.0	0.000	0.000	0.000

Coefficients to use on PVsyst PAN File

AOI	Ave
0	1.000
25	0.997
45	0.986
60	0.947
65	0.932
70	0.876
75	0.830
80	0.721
90	0.000





3.11.2 IAM Polynomial Regression Variables

	Coefficients	Standard Error	RSQ	F Stat	Regression of Sun Squared
a	-6.64904E-11	2.07033E-12	0.999878069	668329.7954	64.59625265
b	1.4568E-08	5.66986E-10	0.004013586	489	0.007877241
c	-1.20603E-06	5.89218E-08			
d	4.56762E-05	2.88622E-06			
e	-0.00077211	6.68892E-05			
f	0.004451941	0.000635733			
Constant	0.996302653	0.001818171			

3.11.3 IAM Polynomial Regression Variables Definitions

a	n	se _n	r ₂	F	SS _{reg}
b	m _{n-1}	se _{n-1}	se _y	df	SS _{resid}
c			
d			
e			
f	m ₁	se ₁			
Constant	b	se _b			


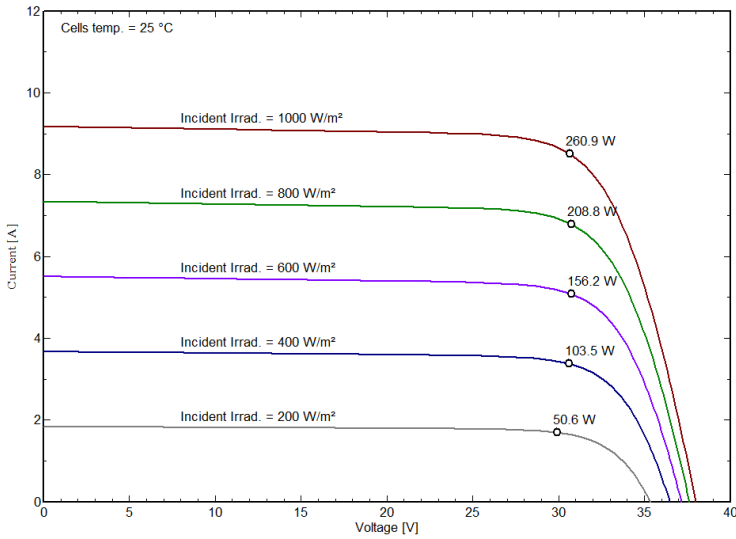
Variable	Description
m _i	The array of constant multipliers for the straight-line equation
b	The constant value of y when x=0
se _i	The standard error values for the coefficients, m _i
se _b	The standard error value for the constant b
r ₂	The coefficient of determination
se _y	The standard error for the y estimate
F	The F statistic, or the F-observed value
df	The number of degrees of freedom
SS _{reg}	The regression sum of squares
SS _{resid}	The residual sum of squares



3.12 PAN File Creation (Vsys = 1000V)
3.12.1 SS-BM270NE

	PVSYST V6.43	Renewable Energy Test Center (United states)	21/04/17 11h41																								
	<p align="center">RETC Project Report: C-CA-1702-TVK-010 46457 Landing Pkwy, Fremont, CA 94538 retc-ca.com 510-226-1635</p>																										
<p>Characteristics of a PV module</p>																											
<p>Manufacturer, model : Shinsung E&G Co., Ltd., SS-BM270NE Data source : RETC-TVK010-170421</p>																											
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Module size (W x L)	0.992 x 1.650	m ²	Rough module area	Amodule 1.64 m ²																							
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<p align="center">PV module: Shinsung E&G Co., Ltd., SS-BM270NE</p>																											

3.12.2 SS-BM260NE

	PVSYST V6.43	Renewable Energy Test Center (United states)	21/04/17 11h56																								
	<p align="center">RETC Project Report: C-CA-1702-TVK-010 46457 Landing Pkwy, Fremont, CA 94538 retc-ca.com 510-226-1635</p>																										
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3.12.3 SS-BM365NE

	PVSYST V6.43	Renewable Energy Test Center (United states)	21/04/17 13h05																								
	<p align="center">RETC Project Report: C-CA-1702-TVK-010 46457 Landing Pkwy, Fremont, CA 94538 retc-ca.com 510-226-1635</p>																										
<p>Characteristics of a PV module</p>																											
<p>Manufacturer, model : Shinsung E&G Co., Ltd., SS-BM265NE Data source : RETC-TVK010-170421</p>																											
<table border="0"> <tr> <td>STC power (manufacturer)</td> <td>Pnom</td> <td>265 Wp</td> <td>Technology</td> <td>Si-mono</td> </tr> <tr> <td>Module size (W x L)</td> <td>0.992 x 1.650</td> <td>m²</td> <td>Rough module area</td> <td>Amodule 1.64 m²</td> </tr> <tr> <td>Number of cells</td> <td>1 x 60</td> <td></td> <td>Sensitive area (cells)</td> <td>Acells 1.47 m²</td> </tr> </table>				STC power (manufacturer)	Pnom	265 Wp	Technology	Si-mono	Module size (W x L)	0.992 x 1.650	m ²	Rough module area	Amodule 1.64 m ²	Number of cells	1 x 60		Sensitive area (cells)	Acells 1.47 m ²									
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Number of cells	1 x 60		Sensitive area (cells)	Acells 1.47 m ²																							
<p>Specifications for the model (manufacturer or measurement data)</p> <table border="0"> <tr> <td>Reference temperature</td> <td>TRef</td> <td>25 °C</td> <td>Reference irradiance</td> <td>GRef</td> <td>1000 W/m²</td> </tr> <tr> <td>Open circuit voltage</td> <td>Voc</td> <td>38.1 V</td> <td>Short-circuit current</td> <td>Isc</td> <td>9.18 A</td> </tr> <tr> <td>Max. power point voltage</td> <td>Vmpp</td> <td>30.8 V</td> <td>Max. power point current</td> <td>Impp</td> <td>8.62 A</td> </tr> <tr> <td>=> maximum power</td> <td>Pmpp</td> <td>265.5 W</td> <td>Isc temperature coefficient</td> <td>mulsc</td> <td>3.7 mA/°C</td> </tr> </table>				Reference temperature	TRef	25 °C	Reference irradiance	GRef	1000 W/m ²	Open circuit voltage	Voc	38.1 V	Short-circuit current	Isc	9.18 A	Max. power point voltage	Vmpp	30.8 V	Max. power point current	Impp	8.62 A	=> maximum power	Pmpp	265.5 W	Isc temperature coefficient	mulsc	3.7 mA/°C
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<p>One-diode model parameters</p> <table border="0"> <tr> <td>Shunt resistance</td> <td>Rshunt</td> <td>170 ohm</td> <td>Diode saturation current</td> <td>IoRef</td> <td>0.167 nA</td> </tr> <tr> <td>Serie resistance</td> <td>Rserie</td> <td>0.28 ohm</td> <td>Voc temp. coefficient</td> <td>MuVoc</td> <td>-131 mV/°C</td> </tr> <tr> <td></td> <td></td> <td></td> <td>Diode quality factor</td> <td>Gamma</td> <td>1.00</td> </tr> <tr> <td>Specified Pmax temper. coeff.</td> <td>muPMaxR</td> <td>-0.42 %/°C</td> <td>Diode factor temper. coeff.</td> <td>muGamma</td> <td>0.000 1/°C</td> </tr> </table>				Shunt resistance	Rshunt	170 ohm	Diode saturation current	IoRef	0.167 nA	Serie resistance	Rserie	0.28 ohm	Voc temp. coefficient	MuVoc	-131 mV/°C				Diode quality factor	Gamma	1.00	Specified Pmax temper. coeff.	muPMaxR	-0.42 %/°C	Diode factor temper. coeff.	muGamma	0.000 1/°C
Shunt resistance	Rshunt	170 ohm	Diode saturation current	IoRef	0.167 nA																						
Serie resistance	Rserie	0.28 ohm	Voc temp. coefficient	MuVoc	-131 mV/°C																						
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<p>Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch</p> <table border="0"> <tr> <td>Reverse characteristics (dark)</td> <td>BRev</td> <td>3.20 mA/V²</td> <td>(quadratic factor (per cell))</td> <td></td> </tr> <tr> <td>Number of by-pass diodes per module</td> <td></td> <td>4</td> <td>Direct voltage of by-pass diodes</td> <td>-0.7 V</td> </tr> </table>				Reverse characteristics (dark)	BRev	3.20 mA/V ²	(quadratic factor (per cell))		Number of by-pass diodes per module		4	Direct voltage of by-pass diodes	-0.7 V														
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<p align="center">PV module: Shinsung E&G Co., Ltd., SS-BM265NE</p>																											



3.12.4 SS-BM275NE

	PVSYST V6.43	Renewable Energy Test Center (United states)	21/04/17 13h15																								
	<p align="center">RETC Project Report: C-CA-1702-TVK-010 46457 Landing Pkwy, Fremont, CA 94538 retc-ca.com 510-226-1635</p>																										
<p>Characteristics of a PV module</p>																											
<p>Manufacturer, model : Shinsung E&G Co., Ltd., SS-BM275NE Data source : RETC-TVK010-170421</p>																											
<table border="0"> <tr> <td>STC power (manufacturer)</td> <td>Pnom</td> <td>275 Wp</td> <td>Technology</td> <td>Si-mono</td> </tr> <tr> <td>Module size (W x L)</td> <td>0.992 x 1.650</td> <td>m²</td> <td>Rough module area</td> <td>Amodule 1.64 m²</td> </tr> <tr> <td>Number of cells</td> <td>1 x 60</td> <td></td> <td>Sensitive area (cells)</td> <td>Acells 1.47 m²</td> </tr> </table>				STC power (manufacturer)	Pnom	275 Wp	Technology	Si-mono	Module size (W x L)	0.992 x 1.650	m ²	Rough module area	Amodule 1.64 m ²	Number of cells	1 x 60		Sensitive area (cells)	Acells 1.47 m ²									
STC power (manufacturer)	Pnom	275 Wp	Technology	Si-mono																							
Module size (W x L)	0.992 x 1.650	m ²	Rough module area	Amodule 1.64 m ²																							
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<p>Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch</p> <table border="0"> <tr> <td>Reverse characteristics (dark)</td> <td>BRev</td> <td>3.20 mA/V²</td> <td>(quadratic factor (per cell))</td> <td></td> </tr> <tr> <td>Number of by-pass diodes per module</td> <td></td> <td>4</td> <td>Direct voltage of by-pass diodes</td> <td>-0.7 V</td> </tr> </table>				Reverse characteristics (dark)	BRev	3.20 mA/V ²	(quadratic factor (per cell))		Number of by-pass diodes per module		4	Direct voltage of by-pass diodes	-0.7 V														
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<p>Model results for standard conditions (STC: T=25°C, G=1000 W/m², AM=1.5)</p> <table border="0"> <tr> <td>Max. power point voltage</td> <td>Vmpp</td> <td>31.6 V</td> <td>Max. power point current</td> <td>Impp</td> <td>8.71 A</td> </tr> <tr> <td>Maximum power</td> <td>Pmpp</td> <td>275.0 Wc</td> <td>Power temper. coefficient</td> <td>muPmpp</td> <td>-0.42 %/°C</td> </tr> <tr> <td>Efficiency(/ Module area)</td> <td>Eff_mod</td> <td>16.8 %</td> <td>Fill factor</td> <td>FF</td> <td>0.777</td> </tr> <tr> <td>Efficiency(/ Cells area)</td> <td>Eff_cells</td> <td>18.7 %</td> <td></td> <td></td> <td></td> </tr> </table>				Max. power point voltage	Vmpp	31.6 V	Max. power point current	Impp	8.71 A	Maximum power	Pmpp	275.0 Wc	Power temper. coefficient	muPmpp	-0.42 %/°C	Efficiency(/ Module area)	Eff_mod	16.8 %	Fill factor	FF	0.777	Efficiency(/ Cells area)	Eff_cells	18.7 %			
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<p align="center">PV module: Shinsung E&G Co., Ltd., SS-BM275NE</p>																											


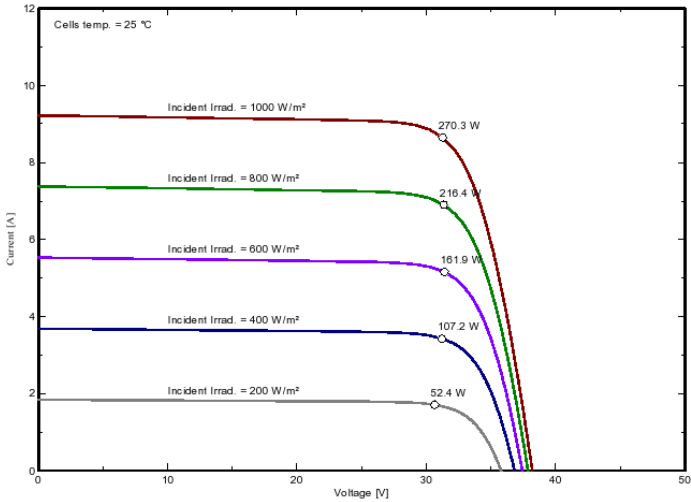


3.12.5 SS-BM280NE

	PVSYST V6.43	Renewable Energy Test Center (United states)	21/04/17 14h15																								
	<p align="center">RETC Project Report: C-CA-1702-TVK-010 46457 Landing Pkwy, Fremont, CA 94538 retc-ca.com 510-226-1635</p>																										
<p>Characteristics of a PV module</p>																											
<p>Manufacturer, model : Shinsung E&G Co., Ltd., SS-BM280NE Data source : RETC-TVK010-170421</p>																											
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STC power (manufacturer)	Pnom	280 Wp	Technology	Si-mono																							
Module size (W x L)	0.992 x 1.650	m ²	Rough module area	Amodule 1.64 m ²																							
Number of cells	1 x 60		Sensitive area (cells)	Acells 1.47 m ²																							
<p>Specifications for the model (manufacturer or measurement data)</p> <table border="0"> <tr> <td>Reference temperature</td> <td>TRef</td> <td>25 °C</td> <td>Reference irradiance</td> <td>GRef</td> <td>1000 W/m²</td> </tr> <tr> <td>Open circuit voltage</td> <td>Voc</td> <td>38.4 V</td> <td>Short-circuit current</td> <td>Isc</td> <td>9.27 A</td> </tr> <tr> <td>Max. power point voltage</td> <td>Vmpp</td> <td>32.0 V</td> <td>Max. power point current</td> <td>Impp</td> <td>8.76 A</td> </tr> <tr> <td>=> maximum power</td> <td>Pmpp</td> <td>280.3 W</td> <td>Isc temperature coefficient</td> <td>mulsc</td> <td>3.7 mA/°C</td> </tr> </table>				Reference temperature	TRef	25 °C	Reference irradiance	GRef	1000 W/m ²	Open circuit voltage	Voc	38.4 V	Short-circuit current	Isc	9.27 A	Max. power point voltage	Vmpp	32.0 V	Max. power point current	Impp	8.76 A	=> maximum power	Pmpp	280.3 W	Isc temperature coefficient	mulsc	3.7 mA/°C
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<p>Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch</p> <table border="0"> <tr> <td>Reverse characteristics (dark)</td> <td>BRev</td> <td>3.20 mA/V²</td> <td>(quadratic factor (per cell))</td> <td></td> </tr> <tr> <td>Number of by-pass diodes per module</td> <td></td> <td>4</td> <td>Direct voltage of by-pass diodes</td> <td>-0.7 V</td> </tr> </table>				Reverse characteristics (dark)	BRev	3.20 mA/V ²	(quadratic factor (per cell))		Number of by-pass diodes per module		4	Direct voltage of by-pass diodes	-0.7 V														
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<p align="center">PV module: Shinsung E&G Co., Ltd., SS-BM280NE</p>																											

3.13 PAN File Creation (Vsys = 1500V)

3.13.1 SS-BM270NE-HV

	PVSYST V6.43	Renewable Energy Test Center (United states)	21/04/17 14h17
	RETC Project Report: C-CA-1702-TVK-010 46457 Landing Pkwy, Fremont, CA 94538 retc-ca.com 510-226-1635		
Characteristics of a PV module			
Manufacturer, model : Shinsung E&G Co., Ltd., SS-BM270NE-HV			
Data source : RETC-TVK010-170421			
STC power (manufacturer)	Pnom 270 Wp	Technology	Si-mono
Module size (W x L)	0.992 x 1.650 m ²	Rough module area	Amodule 1.64 m ²
Number of cells	1 x 60	Sensitive area (cells)	Acells 1.47 m ²
Specifications for the model (manufacturer or measurement data)			
Reference temperature	TRef 25 °C	Reference irradiance	GRef 1000 W/m ²
Open circuit voltage	Voc 38.2 V	Short-circuit current	Isc 9.22 A
Max. power point voltage	Vmpp 31.0 V	Max. power point current	Impp 8.71 A
=> maximum power	Pmpp 270.0 W	Isc temperature coefficient	mulsc 3.7 mA/°C
One-diode model parameters			
Shunt resistance	Rshunt 200 ohm	Diode saturation current	IoRef 0.063 nA
Series resistance	Rserie 0.27 ohm	Voc temp. coefficient	MuVoc -132 mV/°C
		Diode quality factor	Gamma 0.96
Specified Pmax temper. coeff.	muPMaxR -0.42 %/°C	Diode factor temper. coeff.	muGamma -0.001 1/°C
Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch			
Reverse characteristics (dark)	BRev 3.20 mA/V ²	(quadratic factor (per cell))	
Number of by-pass diodes per module	4	Direct voltage of by-pass diodes	-0.7 V
Model results for standard conditions (STC: T=25°C, G=1000 W/m², AM=1.5)			
Max. power point voltage	Vmpp 31.3 V	Max. power point current	Impp 8.65 A
Maximum power	Pmpp 270.3 Wc	Power temper. coefficient	muPmpp -0.42 %/°C
Efficiency(/ Module area)	Eff_mod 16.5 %	Fill factor	FF 0.767
Efficiency(/ Cells area)	Eff_cells 18.3 %		
PV module: Shinsung E&G Co., Ltd., SS-BM270NE-HV			
			

PVsynt Licensed to Renewable Energy Test Center (United states)



3.13.2 SS-BM260NE-HV

	PVSYST V6.43	Renewable Energy Test Center (United states)	21/04/17 14h17																								
	<p align="center">RETC Project Report: C-CA-1702-TVK-010 46457 Landing Pkwy, Fremont, CA 94538 retc-ca.com 510-226-1635</p>																										
<p>Characteristics of a PV module</p>																											
<p>Manufacturer, model : Shinsung E&G Co., Ltd., SS-BM260NE-HV Data source : RETC-TVK010-170421</p>																											
<table border="0"> <tr> <td>STC power (manufacturer)</td> <td>Pnom</td> <td>260 Wp</td> <td>Technology</td> <td>Si-mono</td> </tr> <tr> <td>Module size (W x L)</td> <td>0.992 x 1.650</td> <td>m²</td> <td>Rough module area</td> <td>Amodule 1.64 m²</td> </tr> <tr> <td>Number of cells</td> <td>1 x 60</td> <td></td> <td>Sensitive area (cells)</td> <td>Acells 1.47 m²</td> </tr> </table>				STC power (manufacturer)	Pnom	260 Wp	Technology	Si-mono	Module size (W x L)	0.992 x 1.650	m ²	Rough module area	Amodule 1.64 m ²	Number of cells	1 x 60		Sensitive area (cells)	Acells 1.47 m ²									
STC power (manufacturer)	Pnom	260 Wp	Technology	Si-mono																							
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3.13.3 SS-BM265NE-HV

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3.13.4 SS-BM275NE-HV

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3.13.5 SS-BM280NE-HV

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Annex 1: List of measurement equipment

Description	Identification #	Calibration Due Date
EL Camera	MEQ-CA-009-00	N/A
Luxmeter	MEP-CA-335-00	21/09/2017
Luxmeter	MEP-CA-344-00	12/11/2017
Module IV Tester	MEP-CA-354-00	10/01/2018
Module IV Tester	MEP-CA-355-00	10/01/2018



Annex 2: Statement of the estimated uncertainty of the test results

Temperature measurements using thermocouples (i.e. chamber tests) are estimated to have a $\pm 1.27^{\circ}\text{C}$ uncertainty while the reported performance measurements are subject to $\pm 2.1\%$, $\pm 3.7\%$, $\pm 2.6\%$ uncertainty at STC and $\pm 3.2\%$, $\pm 3.3\%$, $\pm 4.5\%$ uncertainty for non-STC for voltage, current and power respectively to account for the random and systematic errors inherent to the calibration of reference materials, environment, human factor, etc.

Stated quantities represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k=2$



About RETC



RETC, LLC (Renewable Energy Test Center, LLC) is an engineering services, and certification testing provider for photovoltaic and renewable energy products. RETC is TÜV SÜD's exclusive PV Test Laboratory in North America and Global Partner complementing its strategy to deliver "One-Stop-Shop" capabilities for the growth of PV testing and certification services. RETC is ISO 17025 accredited by A2LA, an ILAC affiliated laboratory, and awarded a CBTL status, the highest accreditation in IEC scheme.

RETC offers Outdoor Endurance and Long Term Performance testing capabilities at its Nevada test site for desert / southwest weather conditions and at its Philippines test site for tropical high temperature and high humidity weather conditions. RETC also provides testing services for PV panels, BOS devices (trackers/tracking systems controls and monitoring, inverters, micro-inverters,) and other renewable energy product components to support the growing need for a 3rd party performance validation and monitoring.

RETC brings value from R&D - to Market Entry - to Bankability, focusing on providing "Unequaled Time-to-Market" as a key component of Customer Value-Chain.

At RETC, we believe in the need for cleaner, better, and affordable Solar PV technologies to meet the global demand for energy. We believe in early customer engagement to help ensure a smooth product certification and new product introduction (NPI) process.