



**Test Report**  
September 20, 2024

**Validated PAN File**  
**LONGI Bifacial Module**  
**LR5-72HBD-545M**



*Issued by:*

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

*Issued to:*

**Dr. Hongbin Fang**  
Head of Production Solutions

## RETC Validated PAN File for LONGi LR5-72HBD-545M

Parametric Testing per IEC 61853-1  
Incident Angle Modifier per IEC 61853-2

### Tested Product Configuration

Product	Description	Model Number	BOM	Qty	Remark
Module	144-Half Cell Bifacial PERC PV Module	LR5-72HBD-545M (V4)	5	4	Engineering


Applicable Models	LR5-72HBD-xxxM (V4)	LR5-72HBD-xxxM (V6)
Module Dimensions (LxWxH):	2278 x 1134 x 30 mm	2256 x 1133 x 35 mm
Single Cell Dimensions (LxW):	182 x 91.8 mm	182 x 91 mm
Module Weight:	31.8 Kg	32.3 Kg

**PAN File Generation:** (V4): LR5-72HBD-545M

**PAN File Extrapolation:** (V4): LR5-72HBD-540M, LR5-72HBD-550M, LR5-72HBD-555M, LR5-72HBD-560M, LR5-72HBD-565M  
(V6): LR5-72HBD-535M, LR5-72HBD-540M, LR5-72HBD-545M, LR5-72HBD-550M

Client	Company	<b>LONGi Green Energy Technology Co., Ltd.</b> No. 388, Middle Hangtian Road Chang'an District, Xi'an, Shaanxi 710100, P.R. China
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Test Site	Associated Test Laboratory	Jiaxing, Zhejiang China
	Contact Person	<b>Manpreet Kaur</b> Project Manager O: 510-226-1635 – F: 510-952-4351 Email: manpreet@retc-ca.com

Reviewed by:	Angelico Siason			
Samples Received:	7/13/2023			
Test Date (Start/End):	10/23/2023 – 2/21/2024			
	9/19/2024			
Submission Date:	V1.0	2/27/2024	Report Issuance	
	V2.0	8/01/2024	Additional PAN File Extrapolations for Applicable Model V6	
	V3.0	8/29/2024	Additional PAN File Extrapolation for 535W Model V6	
	V4.0	9/21/2024	IAM Retest on coupon samples, PAN Files Updated	

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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 provided by the manufacturer and as received by RETC.

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## 1 Test Flow

Standard	Station	LRI-294				LRI-361
		A	B	C	D	A
ENG	Electroluminescence		✓	✓	✓	
IEC 61215:2021	Visual Inspection		✓	✓	✓	
IEC 61215:2021	Maximum Power Determination (MNF)	✓	✓	✓	✓	
IEC 61215:2021	Maximum Power Determination (MNB)		✓	✓	✓	
IEC 61215:2021	LS1 40 kWh/m <sup>2</sup> - Light Soak Stabilization		✓	✓	✓	
IEC 61215:2021	Maximum Power Determination (MNF)	✓	✓	✓	✓	
IEC 61215:2021	LS2 20 kWh/m <sup>2</sup> - Light Soak Stabilization		✓	✓	✓	
IEC 61215:2021	Maximum Power Determination (MNF)	✓	✓	✓	✓	
IEC 61215:2021	Maximum Power Determination (MNB)		✓	✓	✓	
IEC 61853	Measurement of Temperature Coefficients		✓			
IEC 61853	Multi-Irradiances @15C		✓	✓	✓	
IEC 61853	Multi-Irradiances @25C		✓	✓	✓	
IEC 61853	Multi-Irradiances @50C		✓	✓	✓	
IEC 61853	Multi-Irradiances @75C		✓	✓	✓	
IEC 61853	AOI Measurement					✓
IEC 61853	IAM Computation					✓
IEC 61853	PAN File Creation		✓	✓	✓	✓

✓: Denotes Test Completed

### Notes:

1. **Mono-Front (MNF)** is a flash test where the rear side of the module is blocked with an opaque cover and the front side is exposed to the light source. This test is used to measure the front side mono-facial performance.
2. **Mono-Back (MNB)** is a flash test where the front side of the module is blocked with an opaque cover and the backside of the module is exposed to the light source. This is used to measure the mono-facial performance of the backside of the module with no contributions from the front.

Project: PAN File Creation: LR5-72HBD-545M (BOM-5)

## 2 Sample Allocation

Sample ID	Module ID	Model Number	Test
LRI-294-A	LRRI04139230618700009	LR5-72HBD-545M (V4) (BOM-5)	Control
LRI-294-B	LRRI04139230618700010		Multi-Irr, Multi-Temp, Tempco
LRI-294-C	LRRI04139230618700011		Multi-Irradiances at Multi-Temperatures
LRI-294-D	LRRI04139230618700013		Multi-Irradiances at Multi-Temperatures
LRI-361-A	LRRI00139240900300001	LR5-72HBD (V4) Coupon	AOI/IAM

## 3 Sample Selection and Traceability

Sampling Oversight Details	
Scope of Work	PV Module Sampling
Sampling Dates	June 26 to June 29, 2023
Inspector	Tracy Feng PI Berlin (Shanghai) Co., Ltd.
Module Sampling Location	No. 8369 Shangyuan Road, Caotan Eco-industrial Park, Xi'an Economic and Technological Development Zone, Xi'an, Shannxi, 710100 China
Report #	RETC-LON-018
Report BOM Reference	BOM-5 V4

Project: PAN File Creation: LR5-72HBD-545M (BOM-5)

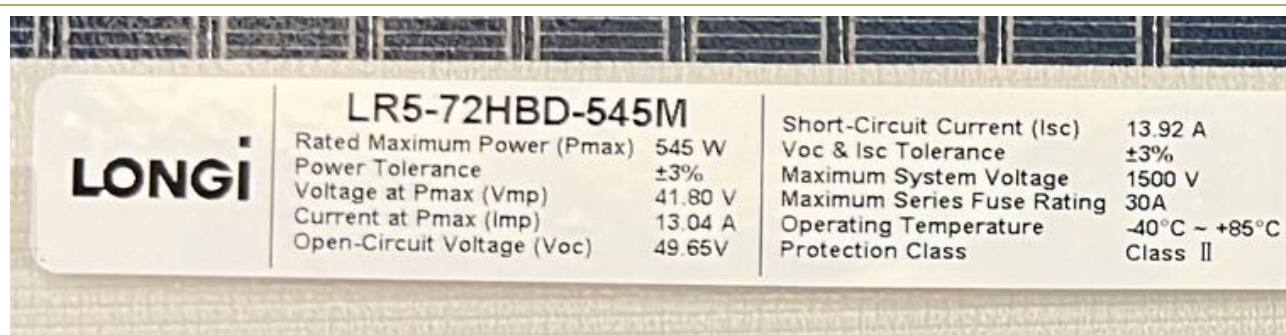
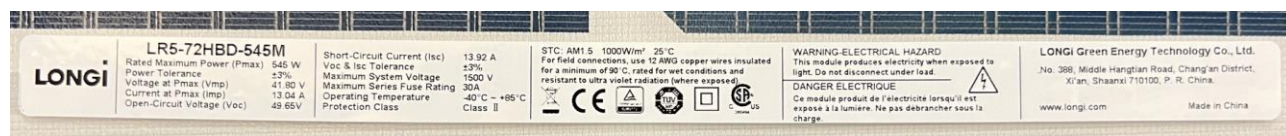
## 4 Test Results

### 4.1 Initial Visual Inspection

Note: Representative Photos

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

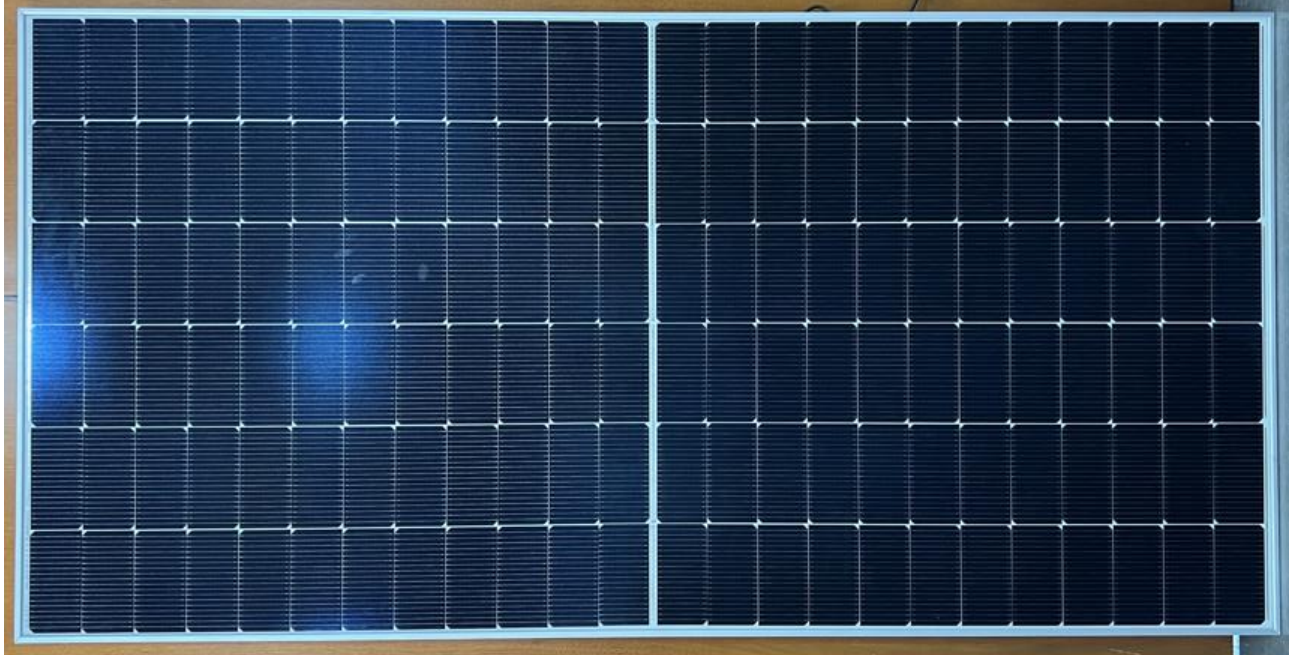
#### LABEL





#### 4.1.1 Visual Inspection – continued

**FRONT**



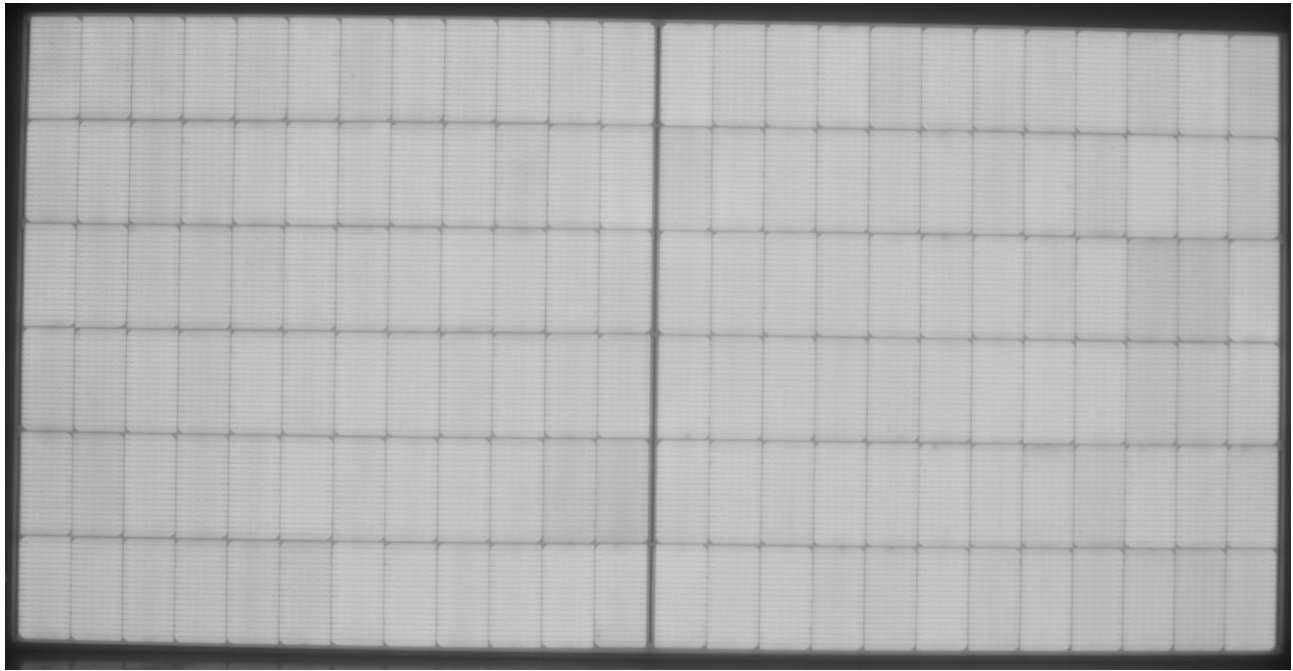
**BACK**



## 4.2 Electroluminescence

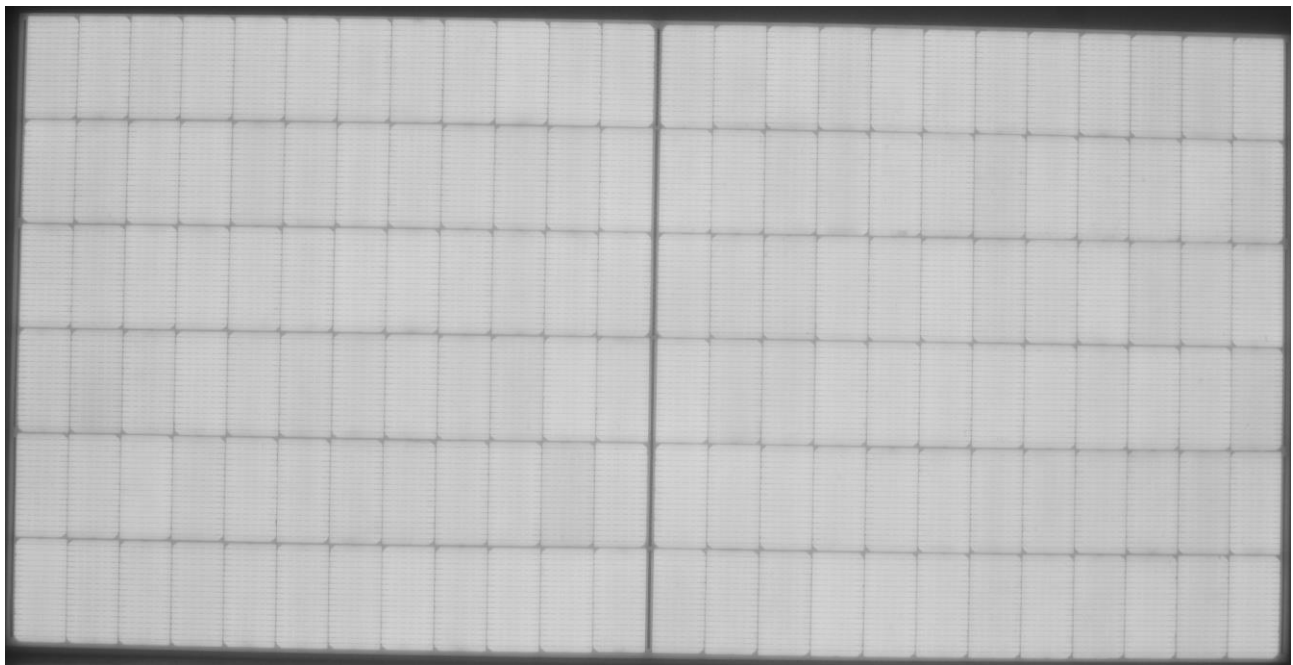
### 4.2.1 LRI-294-B

**LRI-294-B – Initial**



### 4.2.2 LRI-294-C

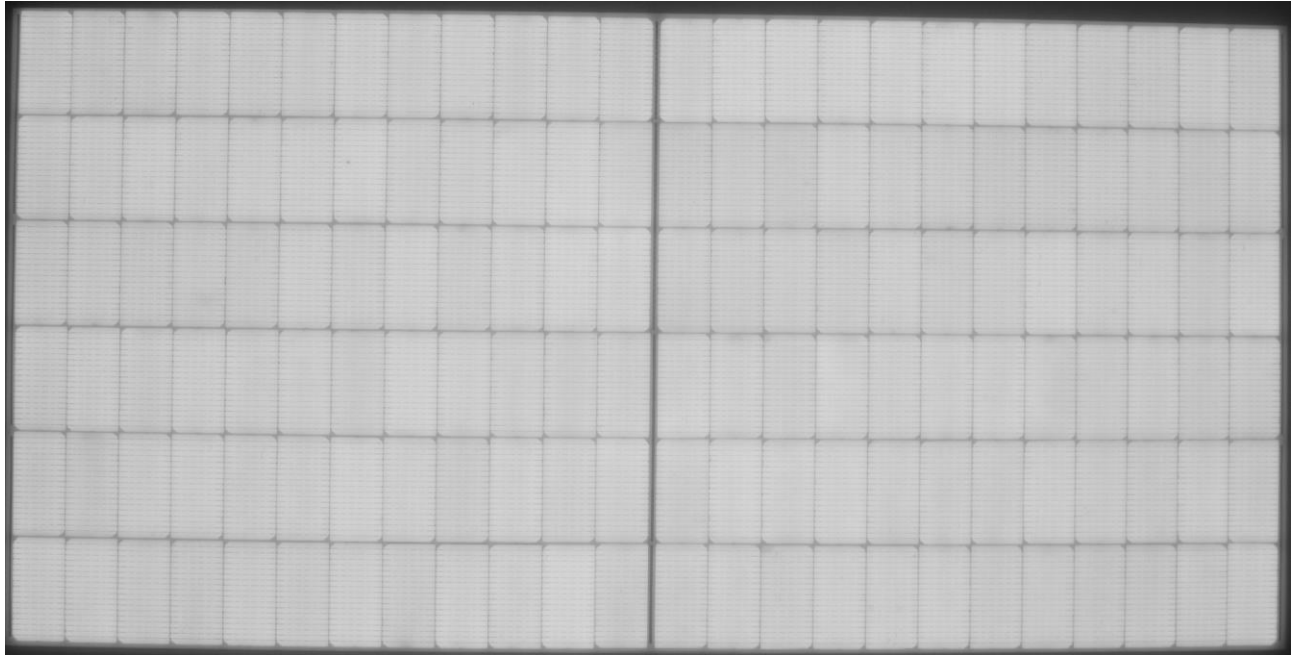
**LRI-294-C – Initial**





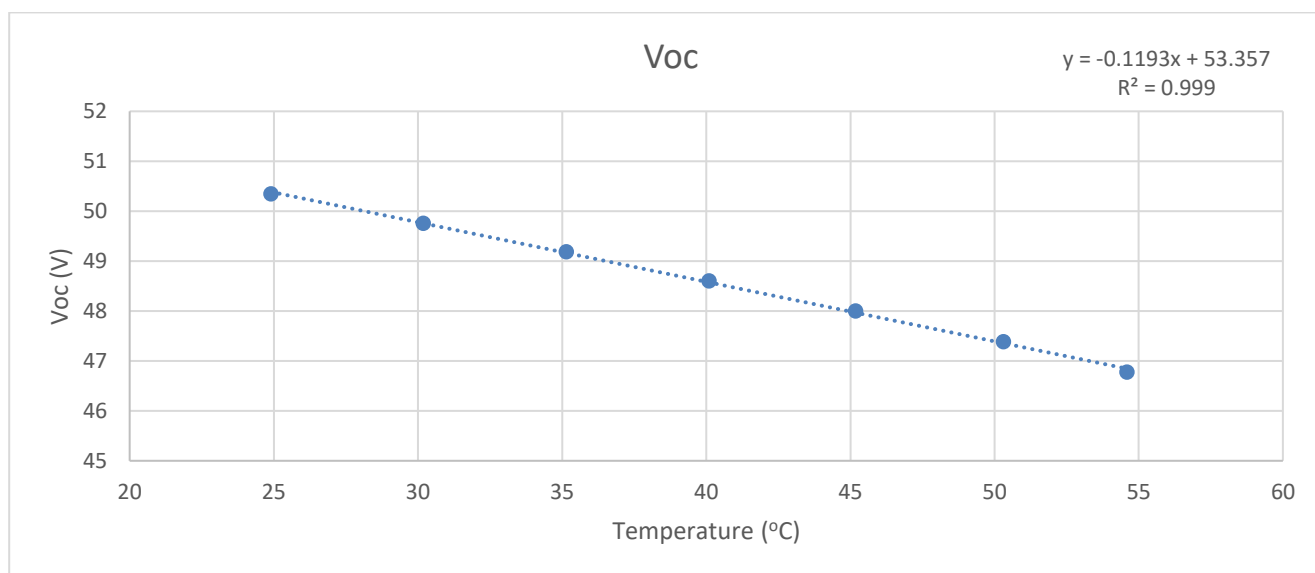
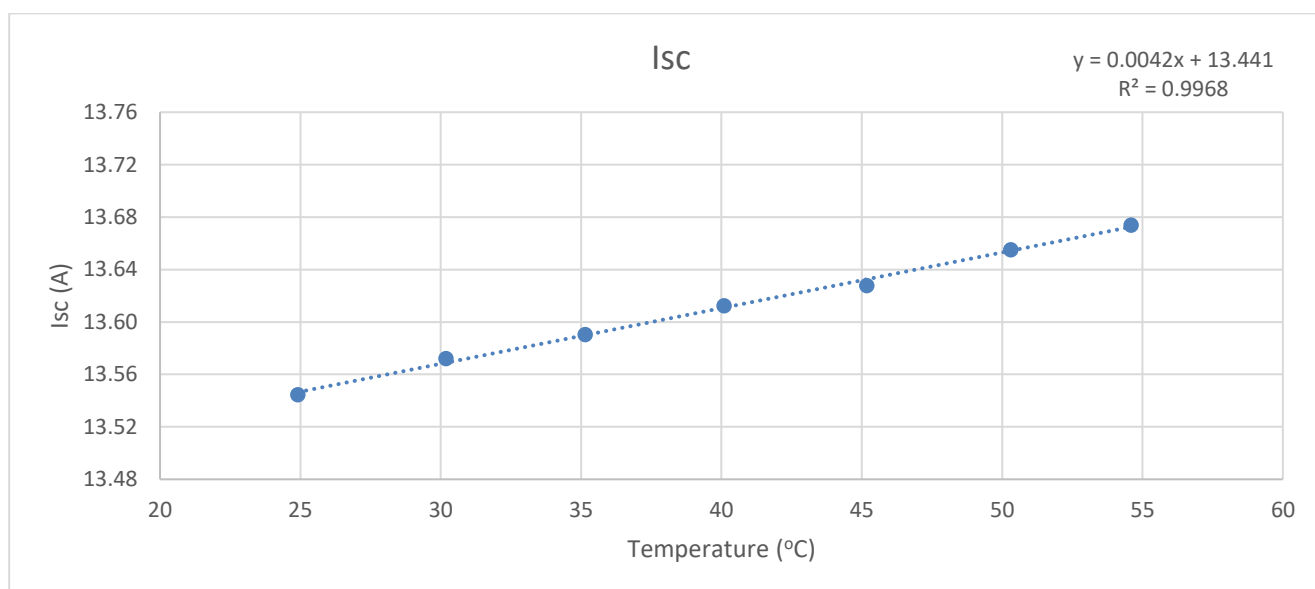
#### 4.2.3 LRI-294-D

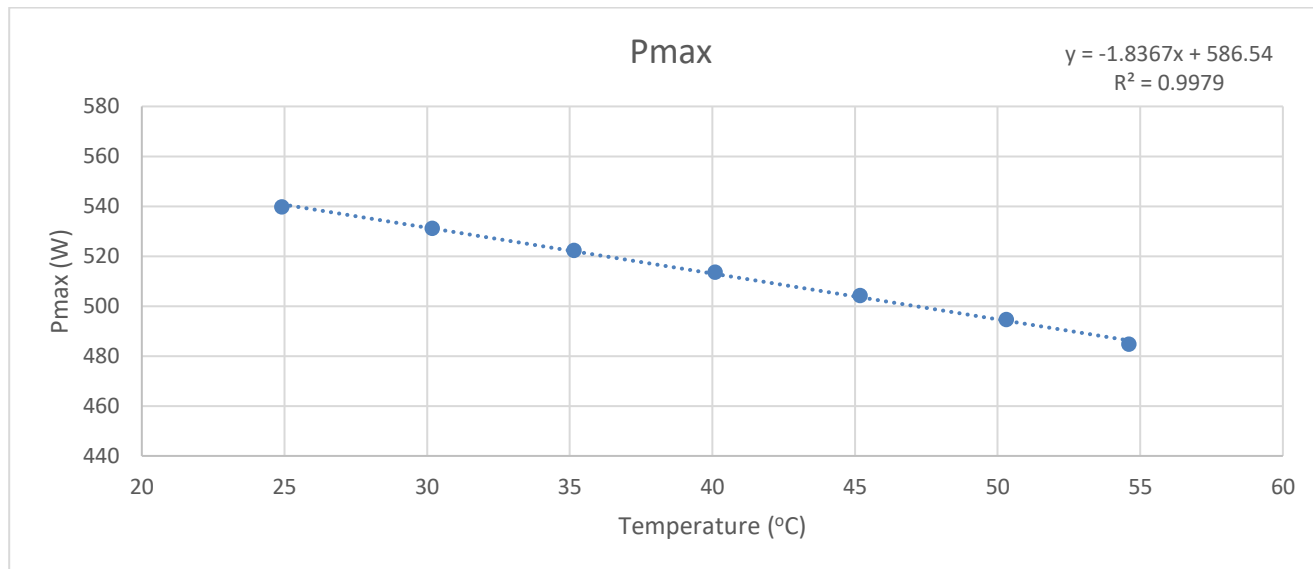
**LRI-294-D – Initial**



### 4.3 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 <sup>2</sup> )		1000
Range of module temperature (high/low) (°C) ... :		54.60 / 24.91
Parameter	Sample ID	Calculated Value
Current: $\alpha$ (%/°C)	LRI-294-B	0.031
Voltage: $\beta$ (%/°C)		-0.237
Peak power: $\delta$ (%/°C)		-0.340





Project: PAN File Creation: LR5-72HBD-545M (BOM-5)

#### 4.4 Maximum Power Determination

Note: Values are normalized to a Stable Control Sample (LRI-294-A)

Total accumulated Light Soak irradiance: 60 kWh/m<sup>2</sup>

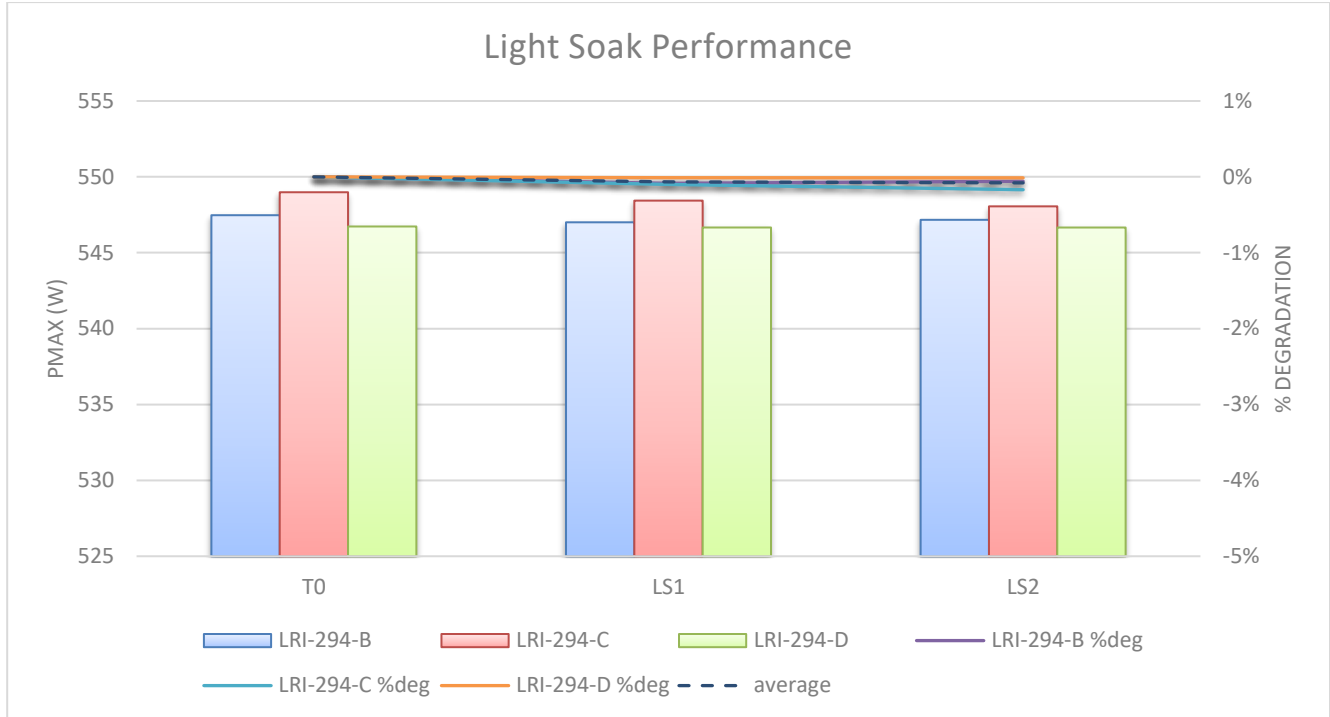
Sample ID	Sequence (Post)	Method	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)
LRI-294-B	Initial	MNF	50.391	42.438	13.652	12.900	547.474	79.582
		<i>MNB</i>	<i>49.850</i>	<i>42.348</i>	<i>10.309</i>	<i>9.588</i>	<i>406.026</i>	<i>79.010</i>
	LS1	MNF	50.475	42.510	13.751	12.868	547.008	78.811
	LS2	MNF	50.481	42.576	13.654	12.852	547.171	79.383
		<i>MNB</i>	<i>49.930</i>	<i>43.006</i>	<i>10.270</i>	<i>9.435</i>	<i>405.779</i>	<i>79.133</i>
LRI-294-C	Initial	MNF	50.403	42.438	13.738	12.936	548.987	79.282
		<i>MNB</i>	<i>49.899</i>	<i>42.880</i>	<i>10.348</i>	<i>9.497</i>	<i>407.236</i>	<i>78.864</i>
	LS1	MNF	50.484	42.528	13.794	12.896	548.436	78.756
	LS2	MNF	50.460	42.567	13.695	12.875	548.059	79.310
		<i>MNB</i>	<i>49.910</i>	<i>42.511</i>	<i>10.308</i>	<i>9.544</i>	<i>405.712</i>	<i>78.862</i>
LRI-294-D	Initial	MNF	50.369	42.417	13.697	12.890	546.731	79.248
		<i>MNB</i>	<i>49.839</i>	<i>42.827</i>	<i>10.281</i>	<i>9.470</i>	<i>405.565</i>	<i>79.153</i>
	LS1	MNF	50.461	42.501	13.758	12.862	546.665	78.742
	LS2	MNF	50.460	42.564	13.668	12.843	546.662	79.265
		<i>MNB</i>	<i>49.915</i>	<i>43.494</i>	<i>10.251</i>	<i>9.305</i>	<i>404.719</i>	<i>79.098</i>

#### 4.4.1 % Degradation

Sample ID	Sequence (Post)	Method	Voc	Vmp	Isc	Imp	Pmax	FF
LRI-294-B	LS1	MNF	0.17%	0.17%	0.72%	-0.25%	-0.09%	-0.97%
	LS2	MNF	0.18%	0.32%	0.02%	-0.38%	-0.06%	-0.25%
		<i>MNB</i>	<i>0.16%</i>	<i>1.55%</i>	<i>-0.38%</i>	<i>-1.59%</i>	<i>-0.06%</i>	<i>0.16%</i>
LRI-294-C	LS1	MNF	0.16%	0.21%	0.41%	-0.31%	-0.10%	-0.66%
	LS2	MNF	0.11%	0.31%	-0.32%	-0.47%	-0.17%	0.04%
		<i>MNB</i>	<i>0.02%</i>	<i>-0.86%</i>	<i>-0.39%</i>	<i>0.49%</i>	<i>-0.37%</i>	<i>0.00%</i>
LRI-294-D	LS1	MNF	0.18%	0.20%	0.45%	-0.21%	-0.01%	-0.64%
	LS2	MNF	0.18%	0.35%	-0.22%	-0.36%	-0.01%	0.02%
		<i>MNB</i>	<i>0.15%</i>	<i>1.56%</i>	<i>-0.29%</i>	<i>-1.74%</i>	<i>-0.21%</i>	<i>-0.07%</i>

Average % degradation: post-LS1 = -0.07% (MNF); post-LS2 = -0.08% (MNF), -0.21% (MNB)

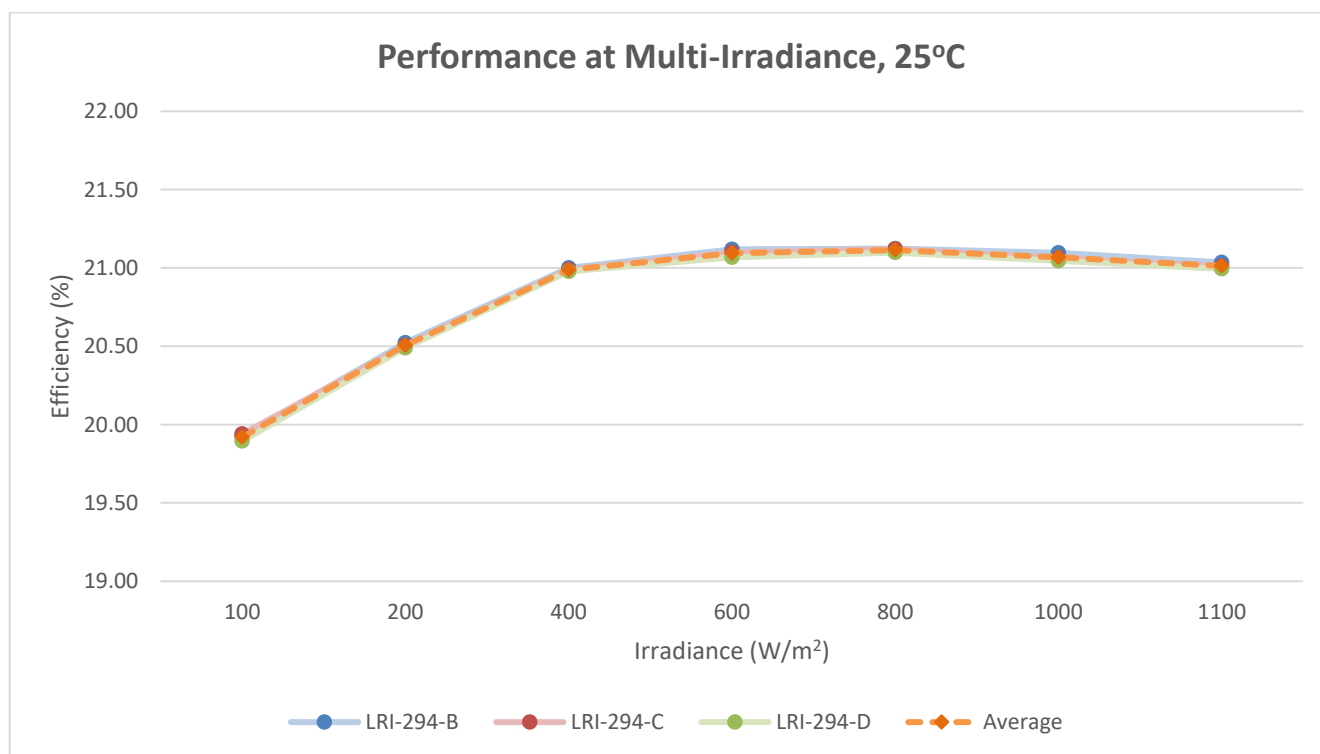
#### 4.4.2 Performance Graph





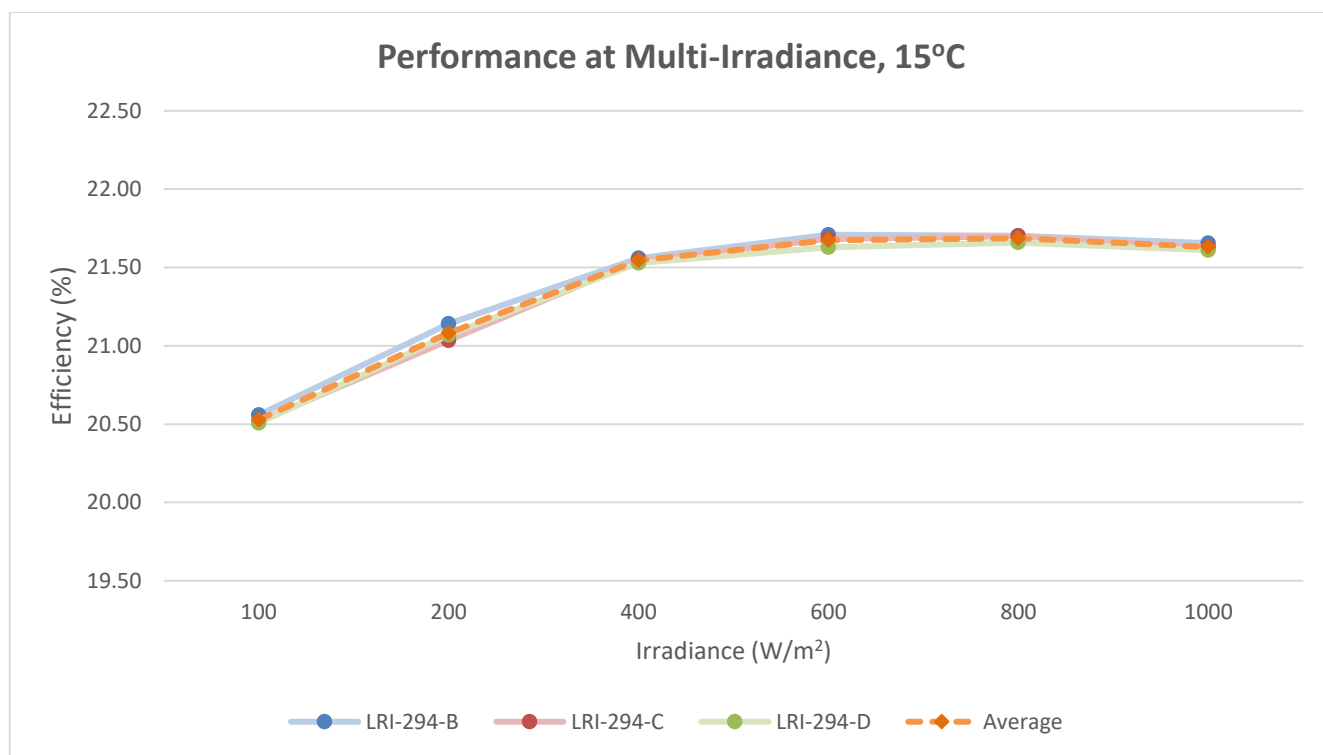
#### 4.5 Performance at Multi-Irradiances, 25°C

Sample ID	IRR (W/m <sup>2</sup> )	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)	Eff (%)
LRI-294-B	100	46.081	39.833	1.362	1.292	51.472	81.983	19.925
	200	47.475	40.577	2.721	2.613	106.027	82.068	20.522
	400	48.815	41.741	5.460	5.199	216.993	81.415	21.000
	600	49.586	41.892	8.174	7.814	327.337	80.763	21.119
	800	50.125	41.869	10.892	10.426	436.534	79.957	21.123
	1000	50.543	42.204	13.622	12.913	544.962	79.152	21.096
	1100	50.720	42.350	14.977	14.114	597.728	78.689	21.035
LRI-294-C	100	46.102	39.863	1.364	1.292	51.509	81.911	19.940
	200	47.491	40.588	2.720	2.610	105.937	82.023	20.505
	400	48.838	41.746	5.452	5.195	216.862	81.451	20.987
	600	49.601	41.906	8.158	7.803	327.011	80.818	21.098
	800	50.148	41.874	10.881	10.423	436.471	79.989	21.120
	1000	50.559	42.221	13.595	12.888	544.141	79.167	21.064
	1100	50.736	42.364	14.952	14.092	596.997	78.699	21.009
LRI-294-D	100	46.067	39.831	1.363	1.290	51.394	81.877	19.895
	200	47.463	40.568	2.716	2.609	105.860	82.109	20.490
	400	48.794	41.705	5.448	5.198	216.764	81.540	20.978
	600	49.558	41.870	8.157	7.799	326.551	80.779	21.068
	800	50.102	42.333	10.875	10.300	436.008	80.019	21.098
	1000	50.519	42.206	13.589	12.881	543.654	79.190	21.045
	1100	50.696	42.333	14.942	14.092	596.568	78.755	20.994



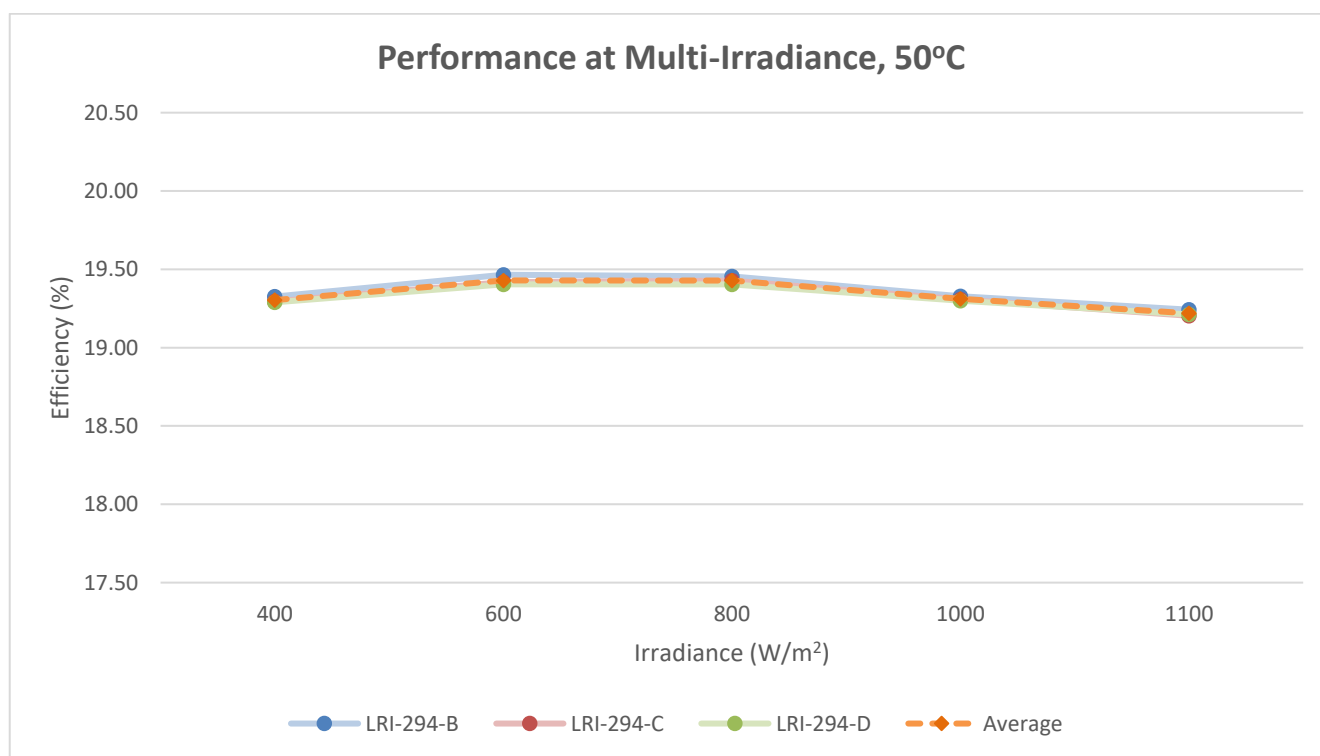
#### 4.6 Performance at Multi-Irradiances, 15°C

Sample ID	IRR (W/m <sup>2</sup> )	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)	Eff (%)
LRI-294-B	100	47.357	40.942	1.355	1.297	53.108	82.750	20.558
	200	48.638	42.073	2.705	2.596	109.219	83.005	21.140
	400	49.957	42.696	5.432	5.218	222.783	82.096	21.560
	600	50.731	43.364	8.134	7.760	336.485	81.546	21.709
	800	51.213	43.274	10.845	10.364	448.498	80.755	21.702
	1000	51.611	43.091	13.554	12.983	559.435	79.974	21.656
LRI-294-C	100	47.349	40.942	1.356	1.295	53.002	82.558	20.517
	200	48.613	42.038	2.701	2.585	108.670	82.747	21.034
	400	50.005	43.226	5.419	5.150	222.610	82.156	21.544
	600	50.772	43.399	8.113	7.743	336.058	81.582	21.682
	800	51.255	43.302	10.822	10.356	448.446	80.849	21.700
	1000	51.632	43.113	13.526	12.958	558.655	79.996	21.626
LRI-294-D	100	47.270	40.909	1.355	1.295	52.977	82.712	20.508
	200	48.671	42.103	2.698	2.585	108.856	82.894	21.070
	400	49.898	42.649	5.420	5.216	222.461	82.254	21.529
	600	50.648	43.290	8.115	7.744	335.225	81.561	21.628
	800	51.174	43.232	10.825	10.354	447.602	80.802	21.659
	1000	51.607	43.090	13.523	12.955	558.245	79.992	21.610



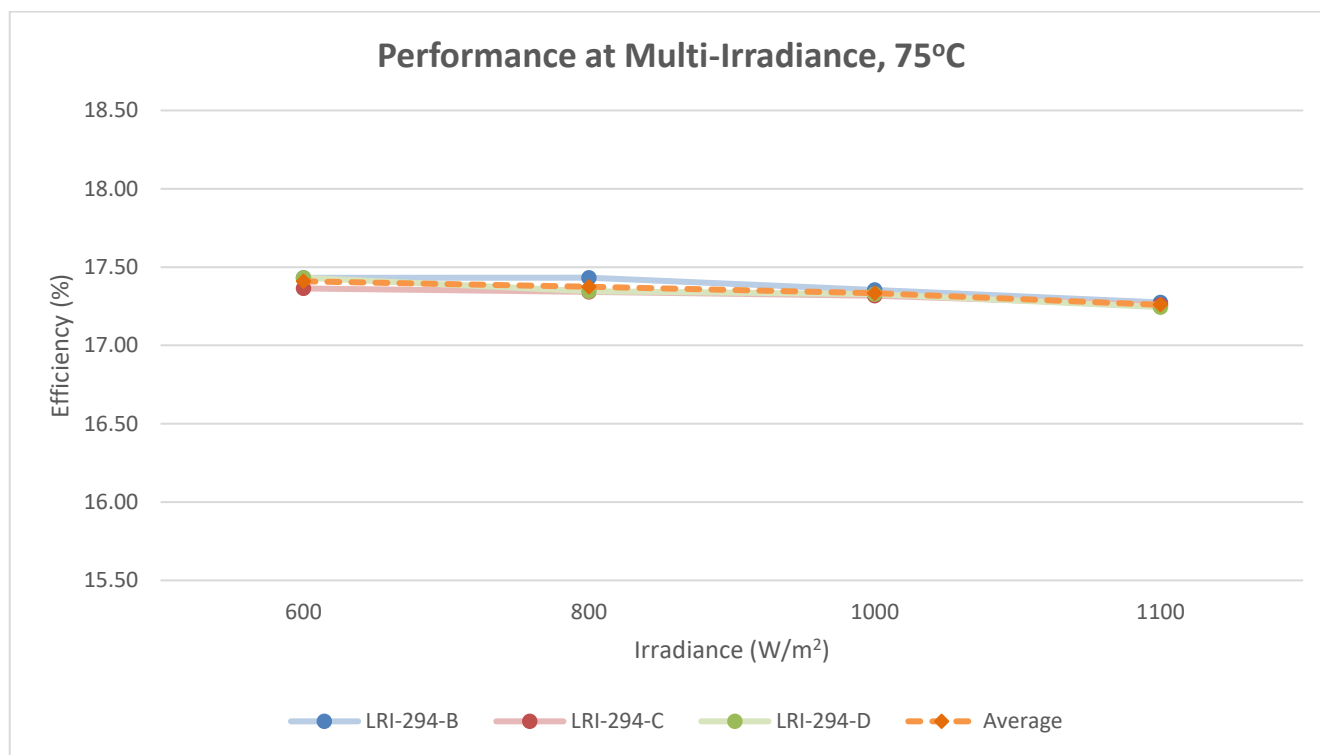
#### 4.7 Performance at Multi-Irradiances, 50°C

Sample ID	IRR (W/m <sup>2</sup> )	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)	Eff (%)
LRI-294-B	400	45.748	38.661	5.497	5.165	199.694	79.405	19.326
	600	46.573	38.902	8.237	7.755	301.704	78.651	19.465
	800	47.158	39.387	10.976	10.208	402.049	77.675	19.455
	1000	47.608	39.754	13.712	12.559	499.281	76.482	19.328
	1100	47.803	39.920	15.077	13.697	546.786	75.868	19.242
LRI-294-C	400	45.739	38.644	5.494	5.159	199.378	79.342	19.295
	600	46.567	38.892	8.221	7.738	300.964	78.615	19.418
	800	47.152	39.380	10.964	10.195	401.490	77.665	19.428
	1000	47.604	39.745	13.698	12.549	498.756	76.489	19.307
	1100	47.798	39.910	15.057	13.673	545.682	75.818	19.203
LRI-294-D	400	45.721	38.184	5.485	5.220	199.328	79.479	19.290
	600	46.541	38.864	8.212	7.739	300.755	78.688	19.404
	800	47.130	39.358	10.946	10.189	401.002	77.734	19.404
	1000	47.578	39.733	13.676	12.548	498.583	76.624	19.301
	1100	47.768	39.887	15.034	13.687	545.918	76.017	19.212



#### 4.8 Performance at Multi-Irradiances, 75°C

Sample ID	IRR (W/m <sup>2</sup> )	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)	Eff (%)
LRI-294-B	600	43.212	36.073	8.233	7.490	270.188	75.942	17.432
	800	43.907	36.648	11.007	9.830	360.260	74.541	17.432
	1000	44.503	37.163	13.807	12.063	448.317	72.963	17.355
	1100	44.753	37.382	15.211	13.131	490.869	72.108	17.275
LRI-294-C	600	43.163	36.029	8.216	7.470	269.130	75.890	17.364
	800	43.865	36.595	10.963	9.793	358.389	74.527	17.342
	1000	44.502	37.171	13.791	12.036	447.375	72.896	17.318
	1100	44.787	37.419	15.187	13.106	490.414	72.102	17.259
LRI-294-D	600	43.248	36.105	8.219	7.484	270.197	76.014	17.433
	800	43.850	36.588	10.960	9.798	358.492	74.593	17.347
	1000	44.482	37.147	13.767	12.050	447.611	73.094	17.327
	1100	44.759	37.381	15.171	13.109	490.023	72.163	17.245



#### 4.9 Performance at LTC, LIC, HTC

Sample ID	Condition	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)	Eff (%)
LRI-294-B	LTC	50.328	43.001	6.777	6.490	279.092	81.832	21.608
	LIC	47.475	40.577	2.721	2.613	106.027	82.068	20.522
	HTC	44.503	37.163	13.807	12.063	448.317	72.963	17.355
LRI-294-C	LTC	50.363	43.043	6.763	6.477	278.776	81.852	21.583
	LIC	47.491	40.588	2.720	2.610	105.937	82.023	20.505
	HTC	44.502	37.171	13.791	12.036	447.375	72.896	17.318
LRI-294-D	LTC	50.403	43.084	6.750	6.474	278.910	81.976	21.594
	LIC	47.463	40.568	2.716	2.609	105.860	82.109	20.490
	HTC	44.482	37.147	13.767	12.050	447.611	73.094	17.327

#### 4.10 Bifaciality Factor

The Bifaciality Factor is determined by the ratio of the average mono-facial backside power to the average mono-facial frontside power of the test samples after light soak (LS) stabilization.

##### Bifaciality Factor: 0.741

Note: This value is used in generating PVsyst PAN files.

Condition	Sample ID	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)
Mono-Back (post LS2)	LRI-294-B	49.930	43.006	10.270	9.435	405.779	79.133
	LRI-294-C	49.910	42.511	10.308	9.544	405.712	78.862
	LRI-294-D	49.915	43.494	10.251	9.305	404.719	79.098
Mono-Front (post LS2)	LRI-294-B	50.481	42.576	13.654	12.852	547.171	79.383
	LRI-294-C	50.460	42.567	13.695	12.875	548.059	79.310
	LRI-294-D	50.460	42.564	13.668	12.843	546.662	79.265

Condition	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmax (W)	FF (%)
Average (Mono-Back)	49.919	43.003	10.276	9.428	405.403	79.031
Average (Mono-Front)	50.467	42.569	13.672	12.857	547.297	79.319
<b>Bifaciality Factor</b>	0.989	1.010	0.752	0.733	<b>0.741</b>	0.996



#### 4.11 Incident Angle Modifier

The angular response testing is performed per IEC61853-2, Indoor method. The module is mounted on a rotating fixture in front of a fixed direct light source. A special setup is designed to reduce off-angle light reflection within the tester. The module is then rotated relative to the light source and measured at each target angle. Each measurement is performed on a single tabbed cell, isolated from the rest of the module circuit. The module Isc is measured at different angles relative to the light source in order to extract the IAM coefficients. The relative transmission into the module is defined by the standard as:

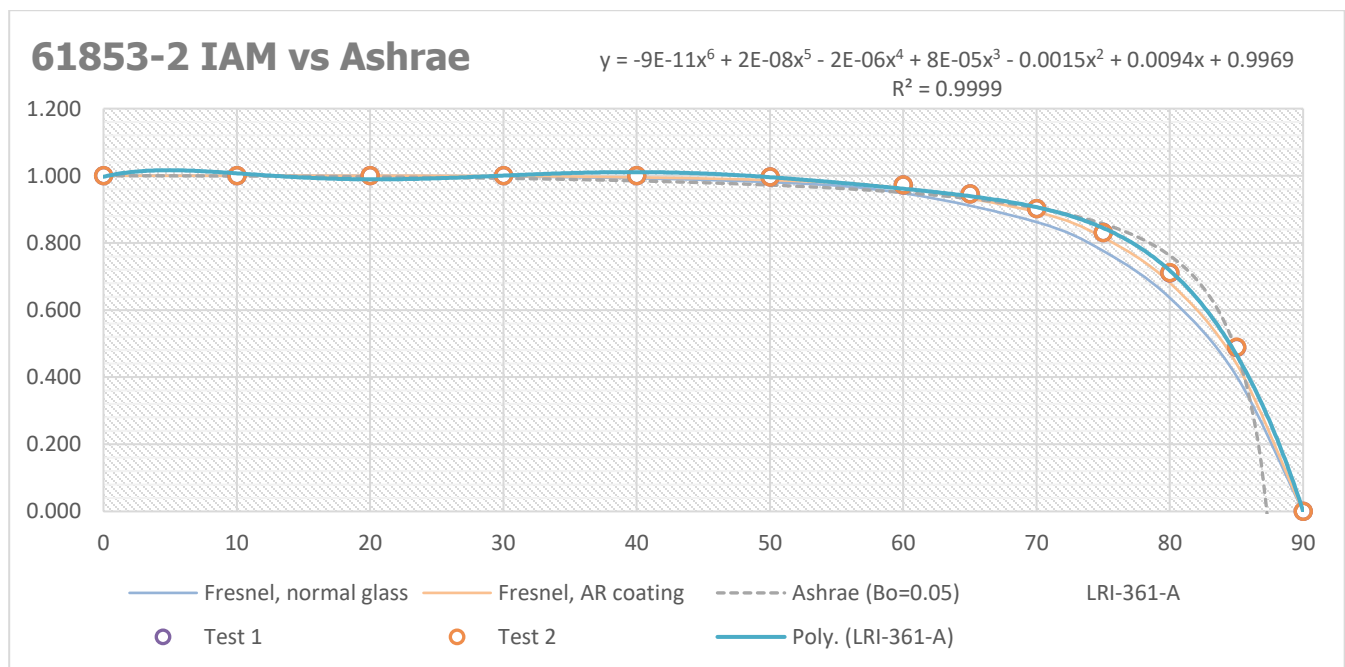
$$\tau(\theta) = \text{Isc}(\theta) / (\cos(\theta) \text{Isc}(0))$$

Where  $\theta$  corresponds to the angle of incidence with respect to the module normal.

#### Measured IAM Coefficients

Angle	LRI-361-A	Values used in PAN Files
0	1.000	←
10	1.000	
20	1.000	
30	1.000	←
40	1.000	
50	0.997	←
60	0.972	←
65	0.946	
70	0.902	←
75	0.830	←
80	0.710	←
85	0.488	←
90	0.000	←

Highlighted values were used on the PVSyst PAN files.



#### 4.11.1 IAM Polynomial Regression Variables

	Coefficients	Standard Error	RSQ	F Stat	Regression of Sum Squared
<b>a</b>	-9.06354E-11	2.27831E-12	0.999868193	618244.9106	18.29061643
<b>b</b>	2.12316E-08	6.34229E-10	0.002220538	489	0.002411157
<b>c</b>	-1.89591E-06	6.70091E-08			
<b>d</b>	7.83655E-05	3.32801E-06			
<b>e</b>	-0.00145525	7.74635E-05			
<b>f</b>	0.009438277	0.000723726			
<b>Constant</b>	0.996935305	0.002211771			

#### 4.11.2 IAM Polynomial Regression Variables Definitions

<b>a</b>	$n$	$SE_n$	$r^2$	$F$	$SS_{reg}$
<b>b</b>	$m_{n-1}$	$SE_{n-1}$	$SE_y$	$df$	$SS_{resid}$
<b>c</b>	...	...			
<b>d</b>	...	...			
<b>e</b>	...	...			
<b>f</b>	$m_1$	$SE_1$			
<b>Constant</b>	$b$	$SE_b$			

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

## 4.12 PAN File Creation

### 4.12.1 LR5-72HBD-545M (V4) PAN File



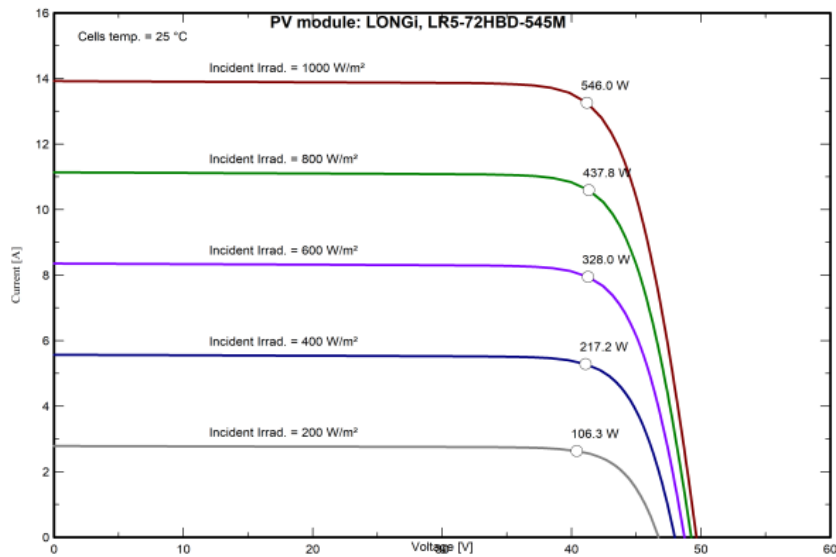
PVsyst V7.4.8

RETC Project Report: C-CS-2306-LRI-294



#### PV module - LR5-72HBD-545M

Manufacturer	LONGi	Commercial data	
Model	LR5-72HBD-545M	Data source :	RETCT-LRI294-240920
Pnom STC power (manufacturer)	545 Wp	Technology	Si-mono
Module size (W x L)	1.134 x 2.278 m <sup>2</sup>	Rough module area (Amodule)	2.58 m <sup>2</sup>
Number of cells	2 x 72	Sensitive area (cells) (Acells)	2.41 m <sup>2</sup>
<b>Specifications for the model (manufacturer or measurement data)</b>			
Reference temperature (TRef)	25 °C	Reference irradiance (GRef)	1000 W/m <sup>2</sup>
Open circuit voltage (Voc)	49.7 V	Short-circuit current (Isc)	13.92 A
Max. power point voltage (Vmpp)	41.8 V	Max. power point current (Impp)	13.04 A
=> maximum power (Pmpp)	545.1 W	Isc temperature coefficient (mulsc)	4.3 mA/°C
<b>One-diode model parameters</b>			
Shunt resistance (Rshunt)	550 Ω	Diode saturation current (IoRef)	0.017 nA
Serie resistance (Rserie)	0.21 Ω	Voc temp. coefficient (MuVoc)	-134 mV/°C
Specified Pmax temper. coeff. (muPMaxR)	-0.34 %/°C	Diode quality factor (Gamma)	0.98
		Diode factor temper. coeff. (muGamma)	0.000 1/°C
<b>Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch</b>			
Reverse characteristics (dark) (BRev)	3.20 mA/V <sup>2</sup>	(quadratic factor (per cell))	
Number of by-pass diodes per module	3	Direct voltage of by-pass diodes	-0.7 V
<b>Model results for standard conditions (STC: T=25 °C, G=1000 W/m<sup>2</sup>, AM=1.5)</b>			
Max. power point voltage (Vmpp)	41.2 V	Max. power point current (Impp)	13.25 A
Maximum power (Pmpp)	546.0 Wp	Power temper. coefficient (muPmpp)	-0.34 %/°C
Efficiency(/ Module area) (Eff_mod)	21.1 %	Fill factor (FF)	0.790
Efficiency(/ Cells area) (Eff_cells)	22.6 %		



## 4.13 PAN File Extrapolation

### 4.13.1 LR5-72HBD-540M (V4) PAN File



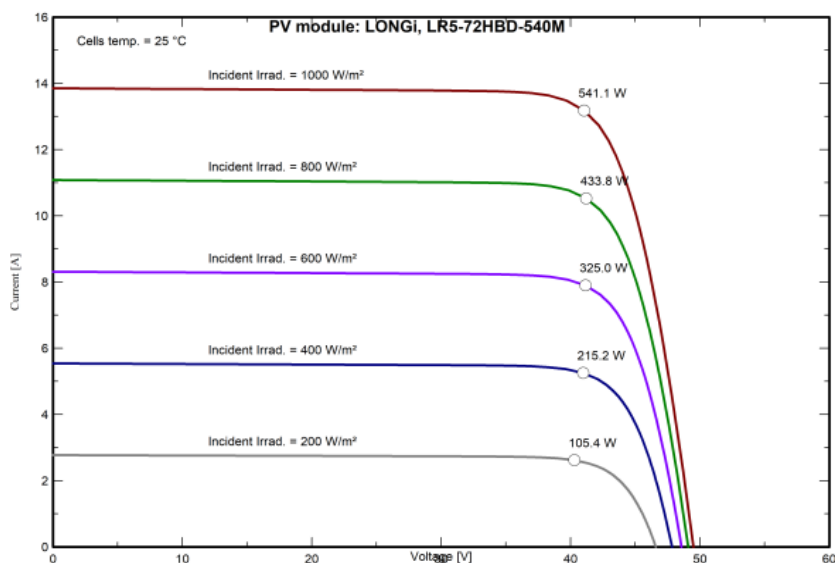
PVsyst V7.4.8

RETC Project Report: C-CS-2306-LRI-294



#### PV module - LR5-72HBD-540M

Manufacturer	LONGi	Commercial data	
Model	LR5-72HBD-540M	Data source :	RETCT-LRI294e-240920
Pnom STC power (manufacturer)	540 Wp	Technology	Si-mono
Module size (W x L)	1.134 x 2.278 m <sup>2</sup>	Rough module area (Amodule)	2.58 m <sup>2</sup>
Number of cells	2 x 72	Sensitive area (cells) (Acells)	2.41 m <sup>2</sup>
<b>Specifications for the model (manufacturer or measurement data)</b>			
Reference temperature (TRef)	25 °C	Reference irradiance (GRef)	1000 W/m <sup>2</sup>
Open circuit voltage (Voc)	49.5 V	Short-circuit current (Isc)	13.85 A
Max. power point voltage (Vmpp)	41.7 V	Max. power point current (Impp)	12.97 A
=> maximum power (Pmpp)	540.2 W	Isc temperature coefficient (mulsc)	4.3 mA/°C
<b>One-diode model parameters</b>			
Shunt resistance (Rshunt)	450 Ω	Diode saturation current (IoRef)	0.015 nA
Serie resistance (Rserie)	0.21 Ω	Voc temp. coefficient (MuVoc)	-134 mV/°C
Specified Pmax temper. coeff. (muPMaxR)	-0.34 %/°C	Diode quality factor (Gamma)	0.97
		Diode factor temper. coeff. (muGamma)	0.000 1/°C
<b>Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch</b>			
Reverse characteristics (dark) (BRev)	3.20 mA/V <sup>2</sup>	(quadratic factor (per cell))	
Number of by-pass diodes per module	3	Direct voltage of by-pass diodes	-0.7 V
<b>Model results for standard conditions (STC: T=25 °C, G=1000 W/m<sup>2</sup>, AM=1.5)</b>			
Max. power point voltage (Vmpp)	41.1 V	Max. power point current (Impp)	13.18 A
Maximum power (Pmpp)	541.1 Wp	Power temper. coefficient (muPmpp)	-0.34 %/°C
Efficiency(/ Module area) (Eff_mod)	20.9 %	Fill factor (FF)	0.789
Efficiency(/ Cells area) (Eff_cells)	22.4 %		

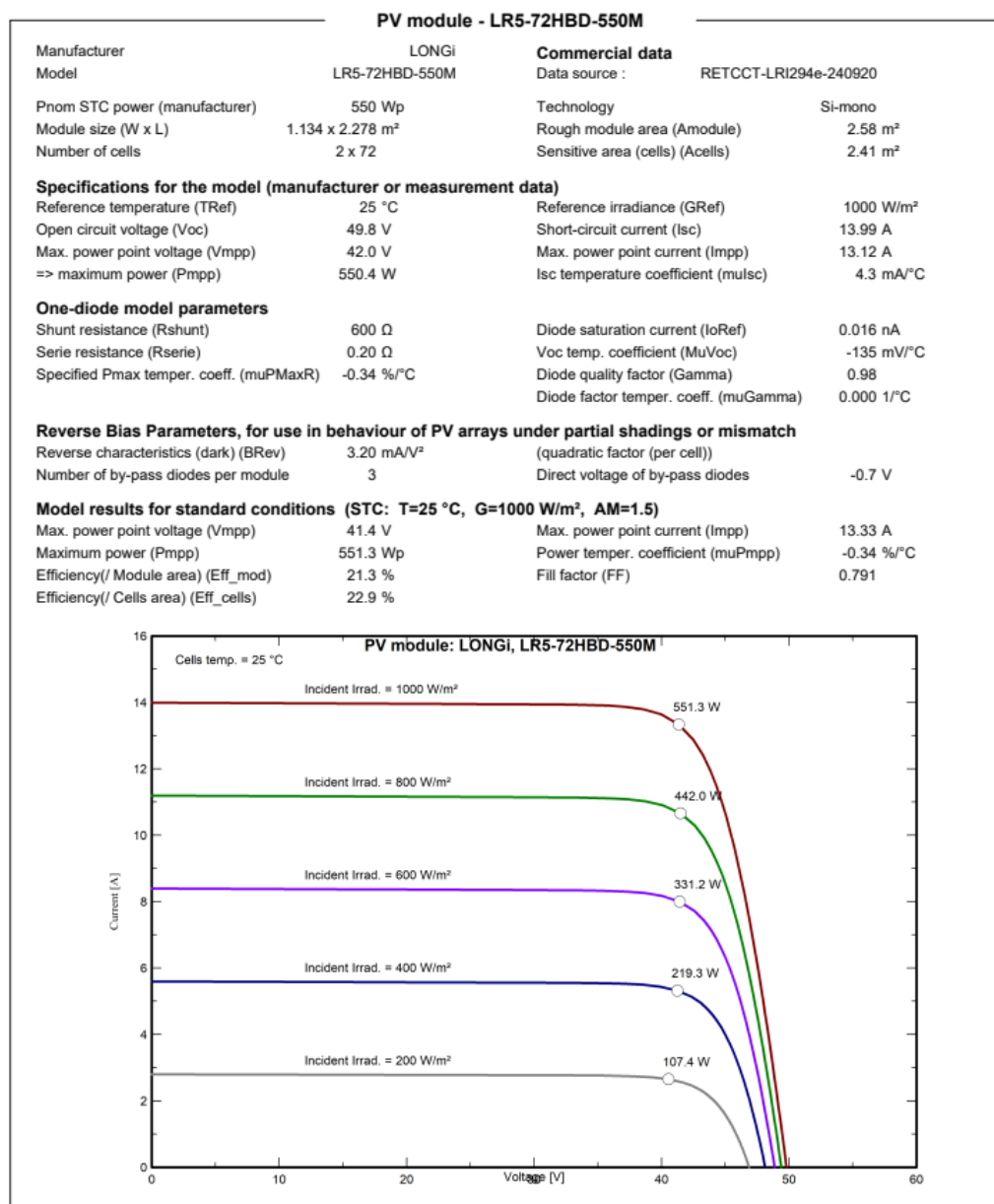


## 4.13.2 LR5-72HBD-550M (V4) PAN File



PVsyst V7.4.8

RETC Project Report: C-CS-2306-LRI-294



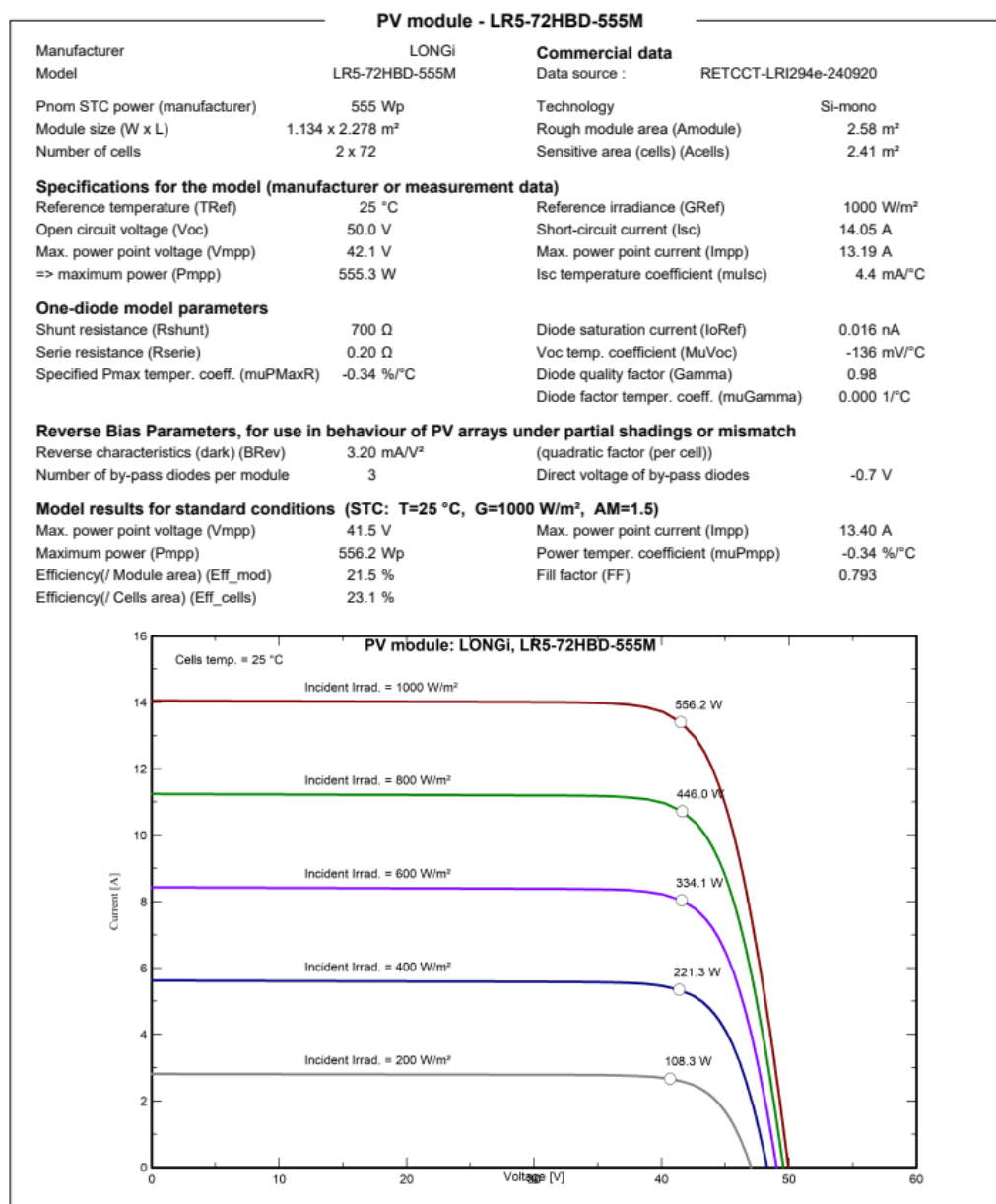


## 4.13.3 LR5-72HBD-555M (V4) PAN File



PVsyst V7.4.8

RETC Project Report: C-CS-2306-LRI-294

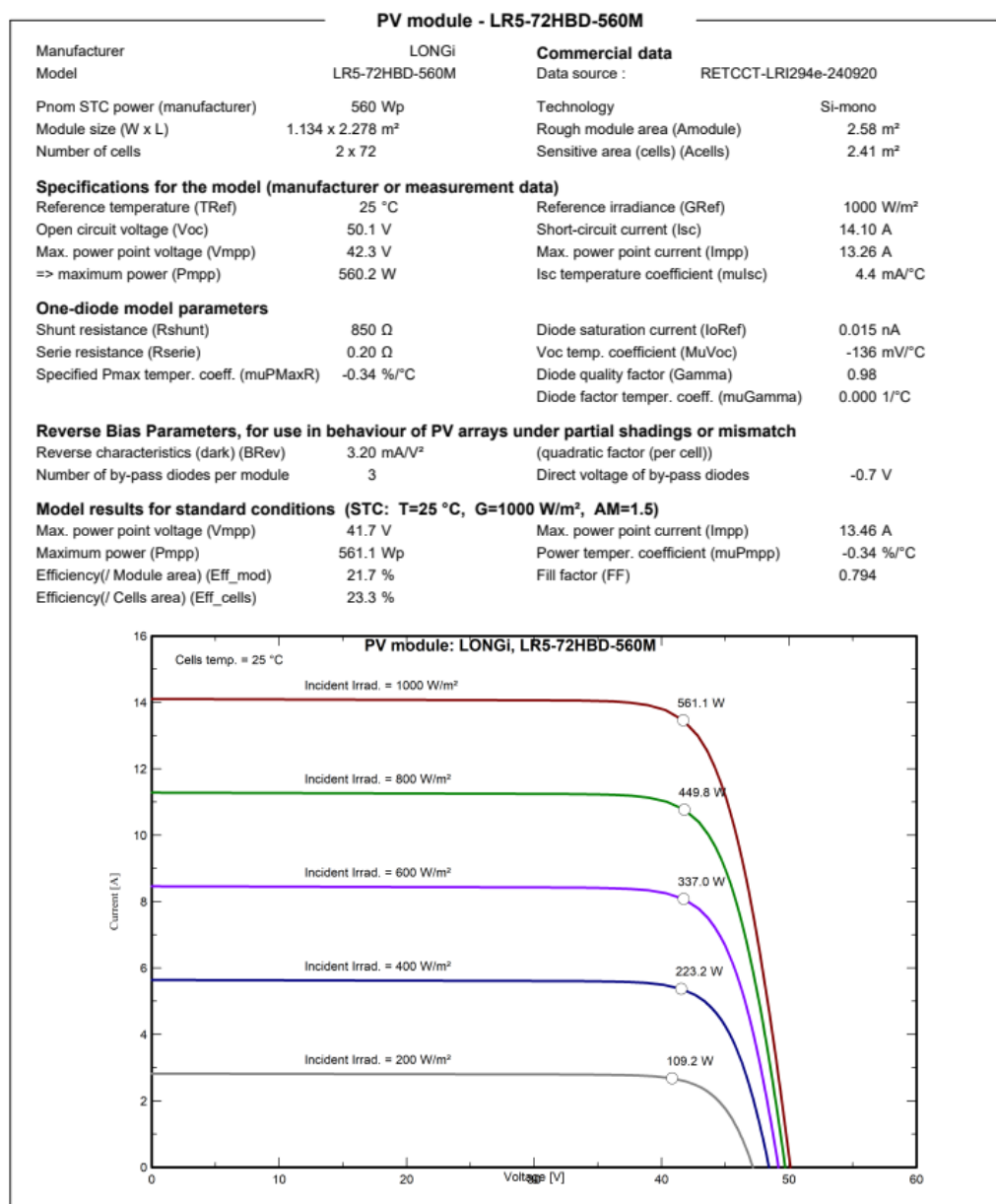


## 4.13.4 LR5-72HBD-560M (V4) PAN File



PVsyst V7.4.8

RETC Project Report: C-CS-2306-LRI-294

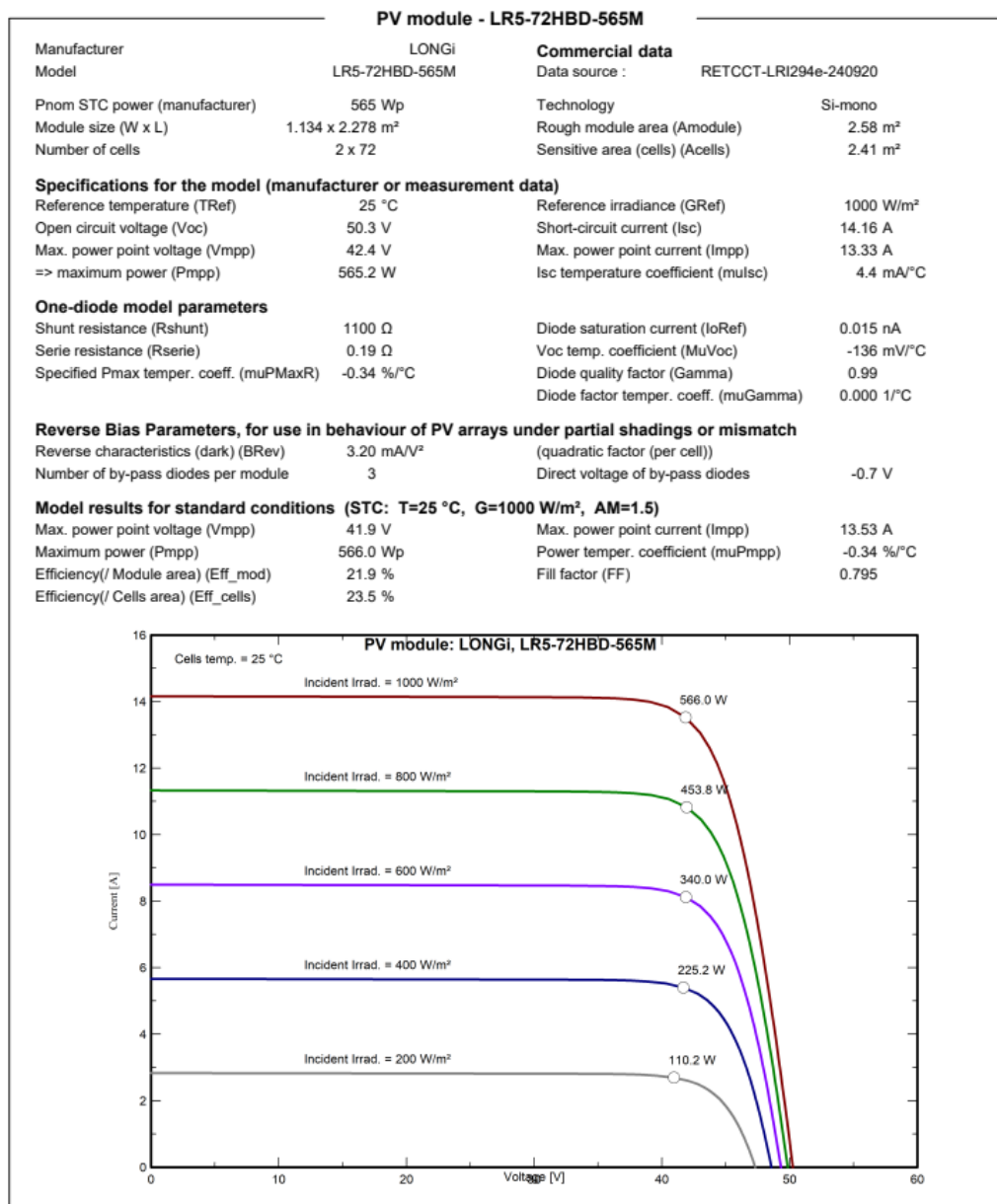


## 4.13.5 LR5-72HBD-565M (V4) PAN File



PVsyst V7.4.8

RETC Project Report: C-CS-2306-LRI-294



## 4.13.6 LR5-72HBD-535M (V6) PAN File



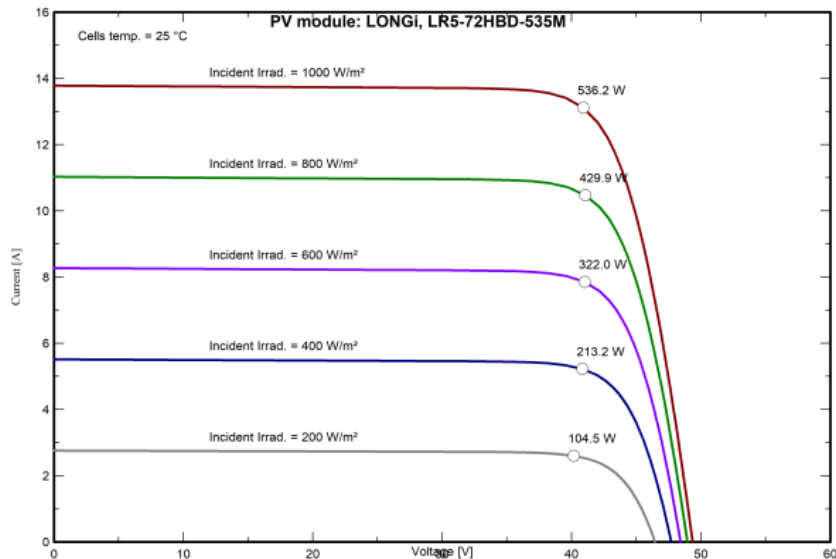
PVsyst V7.4.8

RETC Project Report: C-CS-2306-LRI-294



## PV module - LR5-72HBD-535M

Manufacturer	LONGi	Commercial data	
Model	LR5-72HBD-535M	Data source :	RETCT-LRI360e-240920
Phom STC power (manufacturer)	535 Wp	Technology	Si-mono
Module size (W x L)	1.133 x 2.256 m <sup>2</sup>	Rough module area (Amodule)	2.56 m <sup>2</sup>
Number of cells	2 x 72	Sensitive area (cells) (Acells)	2.38 m <sup>2</sup>
<b>Specifications for the model (manufacturer or measurement data)</b>			
Reference temperature (TRef)	25 °C	Reference irradiance (GRef)	1000 W/m <sup>2</sup>
Open circuit voltage (Voc)	49.4 V	Short-circuit current (Isc)	13.78 A
Max. power point voltage (Vmpp)	41.5 V	Max. power point current (Impp)	12.90 A
=> maximum power (Pmpp)	535.4 W	Isc temperature coefficient (mulsc)	4.3 mA/°C
<b>One-diode model parameters</b>			
Shunt resistance (Rshunt)	430 Ω	Diode saturation current (IoRef)	0.015 nA
Serie resistance (Rserie)	0.21 Ω	Voc temp. coefficient (MuVoc)	-134 mV/°C
Specified Pmax temper. coeff. (muPMaxR)	-0.34 %/°C	Diode quality factor (Gamma)	0.97
		Diode factor temper. coeff. (muGamma)	0.000 1/°C
<b>Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch</b>			
Reverse characteristics (dark) (BRev)	3.20 mA/V <sup>2</sup>	(quadratic factor (per cell))	
Number of by-pass diodes per module	3	Direct voltage of by-pass diodes	-0.7 V
<b>Model results for standard conditions (STC: T=25 °C, G=1000 W/m<sup>2</sup>, AM=1.5)</b>			
Max. power point voltage (Vmpp)	40.9 V	Max. power point current (Impp)	13.10 A
Maximum power (Pmpp)	536.2 Wp	Power temper. coefficient (muPmpp)	-0.34 %/°C
Efficiency(/ Module area) (Eff_mod)	21.0 %	Fill factor (FF)	0.789
Efficiency(/ Cells area) (Eff_cells)	22.5 %		



## 4.13.7 LR5-72HBD-540M (V6) PAN File



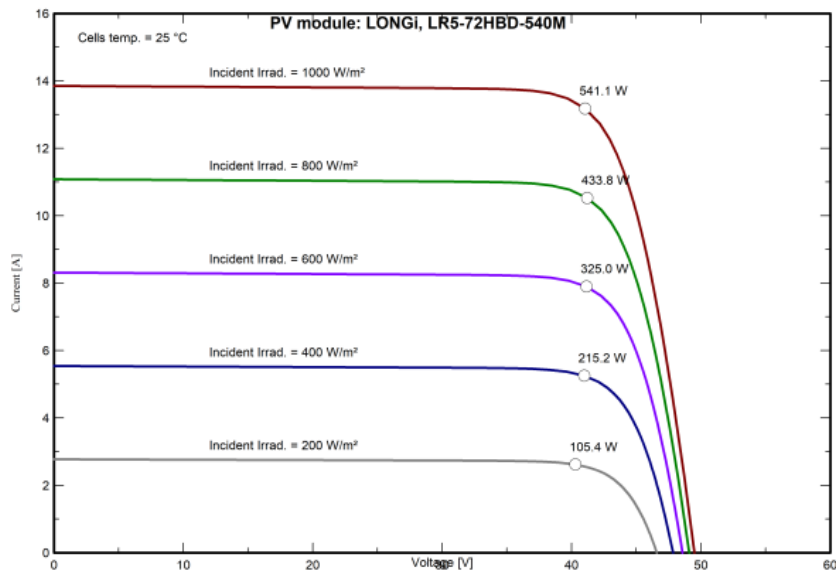
PVsyst V7.4.8

RETC Project Report: C-CS-2306-LRI-294



## PV module - LR5-72HBD-540M

Manufacturer	LONGi	Commercial data	
Model	LR5-72HBD-540M	Data source :	RETCT-LRI360e-240920
Pnom STC power (manufacturer)	540 Wp	Technology	Si-mono
Module size (W x L)	1.133 x 2.256 m <sup>2</sup>	Rough module area (Amodule)	2.56 m <sup>2</sup>
Number of cells	2 x 72	Sensitive area (cells) (Acells)	2.38 m <sup>2</sup>
<b>Specifications for the model (manufacturer or measurement data)</b>			
Reference temperature (TRef)	25 °C	Reference irradiance (GRef)	1000 W/m <sup>2</sup>
Open circuit voltage (Voc)	49.5 V	Short-circuit current (Isc)	13.85 A
Max. power point voltage (Vmpp)	41.7 V	Max. power point current (Impp)	12.97 A
=> maximum power (Pmpp)	540.2 W	Isc temperature coefficient (mulsc)	4.3 mA/°C
<b>One-diode model parameters</b>			
Shunt resistance (Rshunt)	450 Ω	Diode saturation current (IoRef)	0.015 nA
Series resistance (Rserie)	0.21 Ω	Voc temp. coefficient (MuVoc)	-134 mV/°C
Specified Pmax temper. coeff. (muPMaxR)	-0.34 %/°C	Diode quality factor (Gamma)	0.97
		Diode factor temper. coeff. (muGamma)	0.000 1/°C
<b>Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch</b>			
Reverse characteristics (dark) (BRev)	3.20 mA/V <sup>2</sup>	(quadratic factor (per cell))	
Number of by-pass diodes per module	3	Direct voltage of by-pass diodes	-0.7 V
<b>Model results for standard conditions (STC: T=25 °C, G=1000 W/m<sup>2</sup>, AM=1.5)</b>			
Max. power point voltage (Vmpp)	41.1 V	Max. power point current (Impp)	13.18 A
Maximum power (Pmpp)	541.1 Wp	Power temper. coefficient (muPmpp)	-0.34 %/°C
Efficiency(/ Module area) (Eff_mod)	21.2 %	Fill factor (FF)	0.789
Efficiency(/ Cells area) (Eff_cells)	22.7 %		



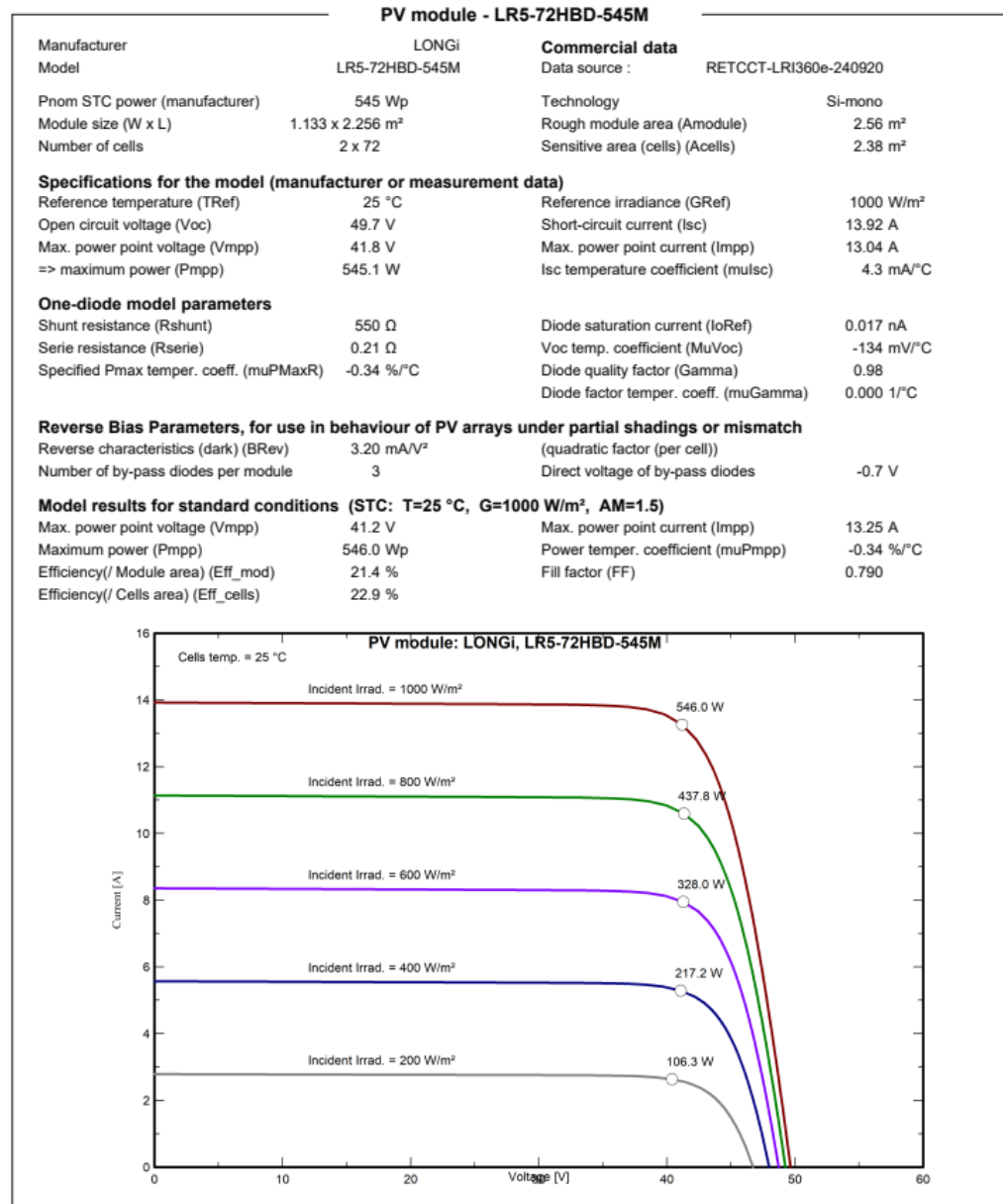


## 4.13.8 LR5-72HBD-545M (V6) PAN File



PVsyst V7.4.8

RETC Project Report: C-CS-2306-LRI-294



## 4.13.9 LR5-72HBD-550M (V6) PAN File



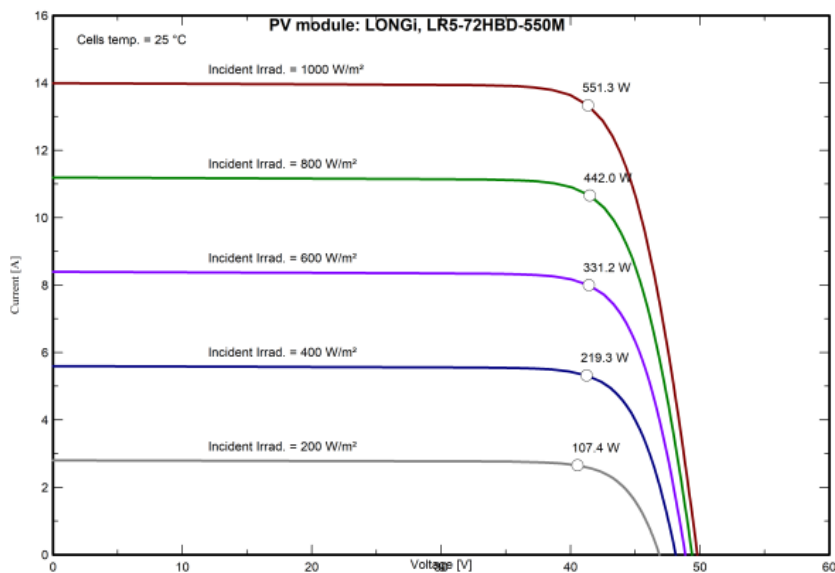
PVsyst V7.4.8

RETC Project Report: C-CS-2306-LRI-294



## PV module - LR5-72HBD-550M

Manufacturer	LONGi	Commercial data	
Model	LR5-72HBD-550M	Data source :	RETCCCT-LRI360e-240920
Pnom STC power (manufacturer)	550 Wp	Technology	Si-mono
Module size (W x L)	1.133 x 2.256 m <sup>2</sup>	Rough module area (Amodule)	2.56 m <sup>2</sup>
Number of cells	2 x 72	Sensitive area (cells) (Acells)	2.38 m <sup>2</sup>
<b>Specifications for the model (manufacturer or measurement data)</b>			
Reference temperature (TRef)	25 °C	Reference irradiance (GRef)	1000 W/m <sup>2</sup>
Open circuit voltage (Voc)	49.8 V	Short-circuit current (Isc)	13.99 A
Max. power point voltage (Vmpp)	42.0 V	Max. power point current (Impp)	13.12 A
=> maximum power (Pmpp)	550.4 W	Isc temperature coefficient (mulsc)	4.3 mA/°C
<b>One-diode model parameters</b>			
Shunt resistance (Rshunt)	600 Ω	Diode saturation current (IoRef)	0.016 nA
Serie resistance (Rserie)	0.20 Ω	Voc temp. coefficient (MuVoc)	-135 mV/°C
Specified Pmax temper. coeff. (muPMaxR)	-0.34 %/°C	Diode quality factor (Gamma)	0.98
		Diode factor temper. coeff. (muGamma)	0.000 1/°C
<b>Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch</b>			
Reverse characteristics (dark) (BRev)	3.20 mA/V <sup>2</sup>	(quadratic factor (per cell))	
Number of by-pass diodes per module	3	Direct voltage of by-pass diodes	-0.7 V
<b>Model results for standard conditions (STC: T=25 °C, G=1000 W/m<sup>2</sup>, AM=1.5)</b>			
Max. power point voltage (Vmpp)	41.4 V	Max. power point current (Impp)	13.33 A
Maximum power (Pmpp)	551.3 Wp	Power temper. coefficient (muPmpp)	-0.34 %/°C
Efficiency(/ Module area) (Eff_mod)	21.6 %	Fill factor (FF)	0.791
Efficiency(/ Cells area) (Eff_cells)	23.1 %		



**Annex 1: List of measurement equipment**

Description	Identification #	Calibration Due Date
Luminometer	JXYQ-024	2025/04/19
Steel tape	JXYQ-034	2025/04/19
Vernier calliper	JXYQ-033	2025/04/19
Pulsed Solar Simulator	JXYQ-043	2025/05/05
Infrared thermometer	JXYQ-021	2025/04/27
Steady state solar simulator	JXYQ-030	2025/05/05
Pyranometer	JXYQ-003	2025/07/16
Pulsed Solar Simulator	JXYQ-111	2024/12/25

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

Under the condition of fixed temperature and irradiance, using Zhongsen transient solar simulator to measure the relative uncertainty of short-circuit current expansion of crystalline silicon photovoltaic modules  $U_{rel} = 2.4\%$ , open-circuit voltage expansion relative uncertainty Degree  $U_{rel} = 0.6\%$ , maximum power expansion relative uncertainty  $U_{rel} = 2.6\%$ . And for performance measurement tests other than  $1000 \text{ W/m}^2$ , the relative uncertainty of short-circuit current expansion of crystalline silicon photovoltaic modules  $U_{rel} = 3.0\%$ , open-circuit voltage expansion relative uncertainty Degree  $U_{rel} = 0.6\%$ , maximum power expansion relative uncertainty  $U_{rel} = 3.1\%$ .

The reported AOI measurements are subject to relative uncertainty of short circuit current,  $U_{rel} = 2.4\%$  for 0 to 40 degrees,  $U_{rel} = 2.6\%$  for 50 to 65 degrees,  $U_{rel} = 2.7\%$  for 70 degrees,  $U_{rel} = 2.9\%$  for 75 degrees,  $U_{rel} = 3.3\%$  for 80 degrees,  $U_{rel} = 4.2\%$  for 85 degrees.

Stated quantities represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of  $k=2$ . Unless otherwise specified (such as inherent clauses in the standard), all compliance and pass/fail statements are binary simple acceptance based on the tolerance interval.

**About RETC**

RETC, LLC (Renewable Energy Test Center, LLC) is an engineering services, and certification testing provider for photovoltaic and renewable energy products. Headquartered in sunny California, USA, with global partners UL, VDE, TUV SUD, TUV Rheinland, and Intertek, complementing its strategy to deliver a One-Stop-Shop capabilities for the growth of PV testing and certification services. RETC is an ILAC affiliated laboratory, ISO 17025 accredited by A2LA, and holds a CBTL status, a distinguished accreditation for global market access in the IEC CB scheme.

RETC provides testing services for PV panels, components (cells, connectors, backsheets), BOS devices (racking, trackers/tracking systems controls and monitoring, inverters, micro-inverters), Energy Storage Systems and other renewable energy product components to support the

growing need for a 3rd party performance validation and monitoring.

RETC offers Outdoor Endurance and Long-Term Performance testing capabilities at its Nevada test site for desert / southwest weather conditions, Chile for high irradiance and at its Philippines test site for tropical high temperature and high humidity weather conditions.

RETC launched the Solar Industry's first Bifacial Module Ranking in collaboration with Black and Veatch and released its inaugural PV Module Index in 2019, the industry's first comprehensive solar module ranking initiative that focuses on Reliability, Performance and a manufacturer's commitment to Quality.