Coverage

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1	RenewSys Introduction
2	PV Value Chain
3	c-Si Wafer based Solar Cell
4	Solar Cell Manufacturing (Including PERC)
5	Solar Module Manufacturing
6	Module Technology Difference
7	Module Design Parameters
8	Module Inspection and Reliability
9	India's PV Manufacturing Capacity & Product Mix
10	Existing Module Technologies & Efficiencies
11	Module Technology Evolution & Roadmap
12	DCR and its Compliances
13	Commercial Outlook

Bhupendra Rawat

21.04.2020, Mumbai

RenewSys®

let there be light

RenewSys

RenewSys is the first integrated manufacturer of **Solar PV Modules** and its key components – **Encapsulants (EVA & POE), Backsheets, & Solar PV Cells.**

RenewSys is the renewable energy arm of the **ENPEE Group**

RENEWSYS BENGALURU

6 Acre, state of the art facility with 10% set aside for a green belt

- **CONSERV® - 1.4 GW**
  Encapsulants (EVA & POE)
- **PRESERV® - 3 GW***
  (Backsheets + Bus Bar Insulation Sheets)

RENEWSYS HYDERABAD

50 Acre, world class facility with Clean room and automated racking

- **DESERV™ - 750 MW**
  PV Modules
- **RESERV® - 130 MW**
  PV Cells

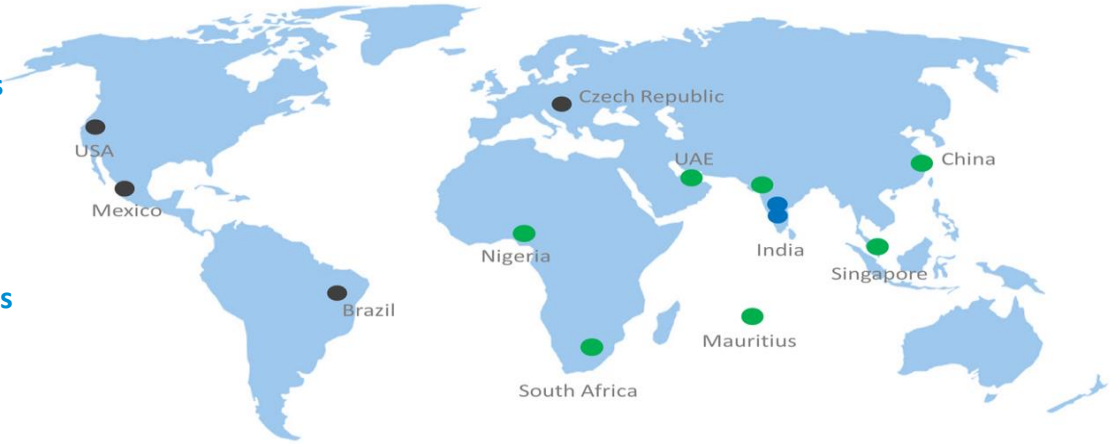
Our Values

Be **Courageous** | Be **Empowered** | Be **Trustworthy** | Be **Fair** | Be **Futuristic**

* For co-extruded Backsheet, Capacity for 3 layered Backsheet 1.8 GW

RenewSys Presence and Exports

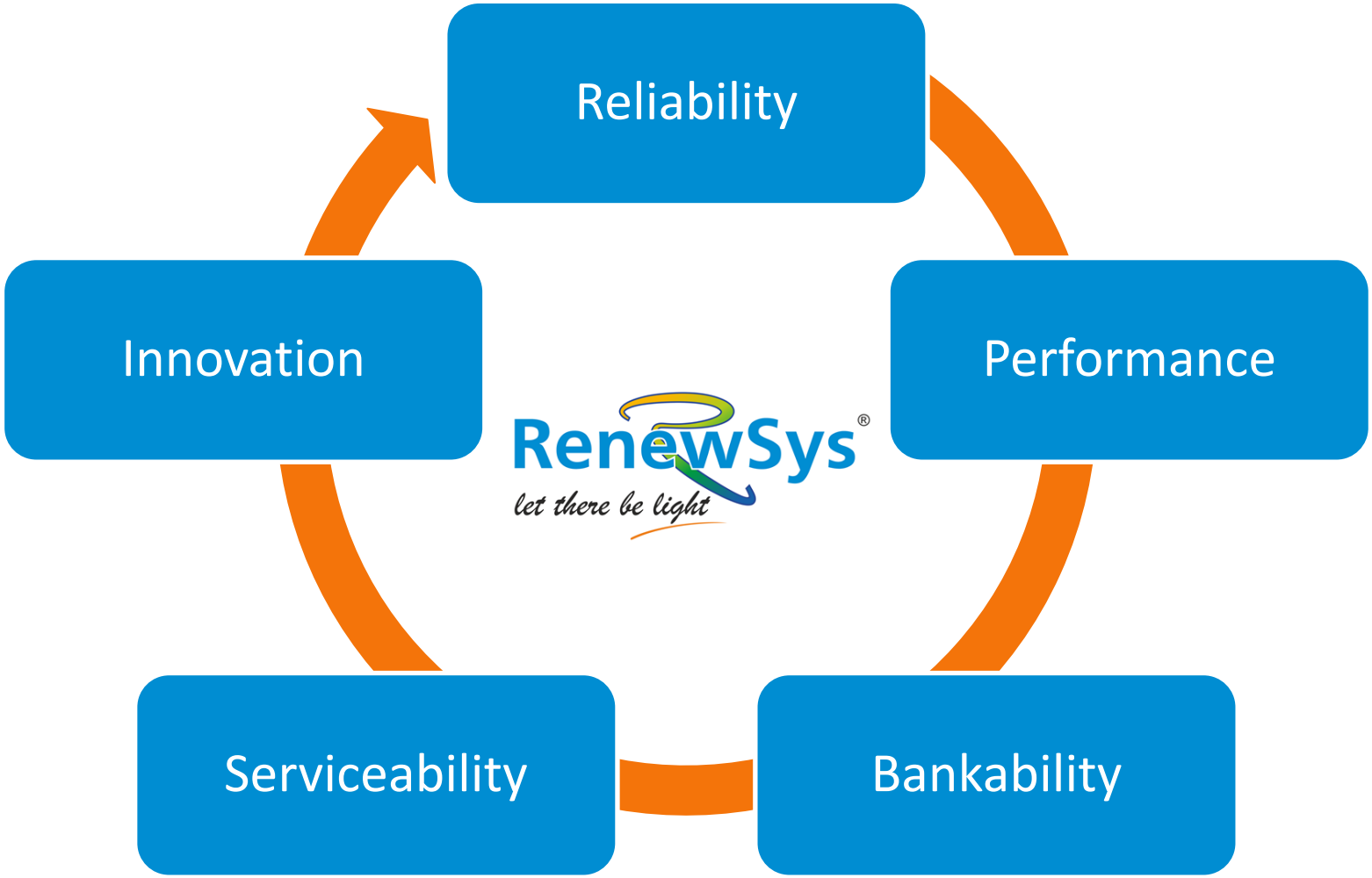
- **Manufacturing Facilities**
- **Offices**
- **Representatives**



- **Exports to 44+ Countries**

- Germany
- Ghana
- India
- Kenya
- Malawi
- Mauritius
- Mozambique
- Namibia
- Netherlands
- Nigeria
- Poland
- Saudi Arabia
- Botswana
- Bulgaria
- Finland
- Seychelles
- Somalia
- Somali Land
- South Africa
- Sudan
- Swaziland
- Sweden
- Switzerland
- Tanzania
- Togo
- United Arab Emirates
- United States
- Zambia
- Zimbabwe

WHY RenewSys ??



RenewSys Reliability

- Investments in state –of-the-art European machinery
- **1st Vertically Integrated manufacturer – PV Modules & Encapsulants, Backsheets, PV Cells**
- One of its kind Reliability Lab for extensive testing of modules
- 7 environmental chambers (no one else in India has) that simulate the stress a module may face over 25+ years Lab
- India's only Intertek recognised Satellite ® laboratory
- Collaborative testing with RenewSys polymer speciality division

Temperature Cycles

UV Testing

Damp Heat

Humidity Freeze

RenewSys Bankability

- Setting industry benchmarks for transparent, reliable business
- RenewSys modules now accepted by major Developers, EPC companies and Financiers, who otherwise only accept 'Tier 1'
- Assurance delivered through:

1. **Range of Certifications**

2. **Insurance** – Product and performance insurance globally Re-insurance offered by Munich Re

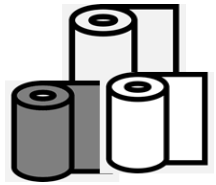
3. **Bankability** – Transparency enhanced with audit by DNV GL - empowers customers with insights

4. **IEC x 3** - Extended reliability testing facility in house with detailed report available- Accreditation for testing IEC x 3 with INTERTEK under progress

Certifications & Serviceability

Meets requirements for – SASO, RRECL etc

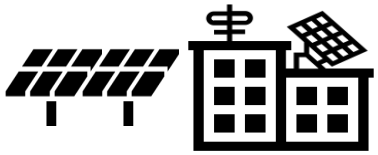
- TUV Certified 61215, 61730, 60068-2-68, 61701, 62716
- IEC TS 62804,61853
- UL Certified: 1703
- SON CAP Certified
- CAN/CSA: 61730
- MCS Certified
- DEWA Listed
- Independently audited by **Solar Buyer**
- BIS NO.: R-63000760



Encapsulants & Backsheet **8.7GW***

PV Modules: **22,50,814***

PV Cells: **235.16 MW***



Installed :**730MW***

*Until Feb 2020

- **Value Led** organisation
- Wide **Network** of offices
- **Group Heritage** of manufacturing excellence of nearly 60 Years

RenewSys Innovation

- India's first Bi-Facial Glass – Backsheet module – DESERV Extreme
- Only Indian module manufacturer to have a dedicated 'Product Excellence Centres'
- Only customer testing facility by Intertek Testing Services (Singapore) Pte. Ltd.
- India's 1st 5 BB and 6 BB solar PV Cells, Made in India
- India's only UL certified POE Encapsulant
- Only manufacturer to extend a free module wellness programme - Dr. PV

ENPEE GROUP

RenewSys is part of the ENPEE GROUP.

$300+ MILLION

3000+ EMPLOYEES

www.enpee.com

An international conglomerate with a rich heritage of nearly 60 YEARS of manufacturing excellence in diverse industries.

ENPEE Group Companies

- Based in Nigeria
- Manufacturing Metal Packaging

- Based in Nigeria
- Cement/ Fibre Cement Sheets

- Based in Nigeria
- Printing Cylinders and Inks, CPP Films

- Based in India
- Packaging Brand Management

- Based in Nigeria
- Soaps, Personal & Home Care, Beauty & Cosmetics

- Based in Nigeria
- Construction, Chemicals, Adhesives, Power Cables

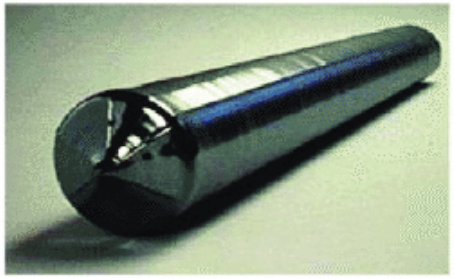
- Based in Nigeria
- Flexible packaging

- Solar PV Modules & Components
- Manufacturing Facilities in Hyderabad & Bengaluru, India

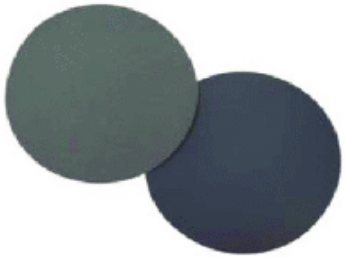
www.enpee.com

PV Value Chain

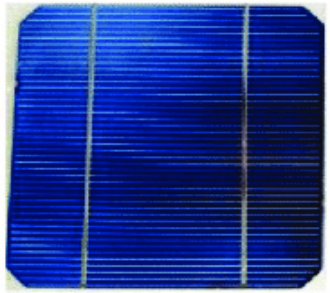
Feedstock



Ingot



Wafer



Solar cell

Module

System

India's presence in the value chain

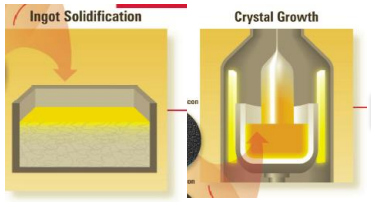
PV Value Chain- Upto Module

Polysilicon

Sand

Polysilicon / pure silicon

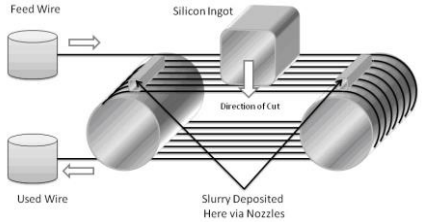
Crystal Growth



Multi

Mono

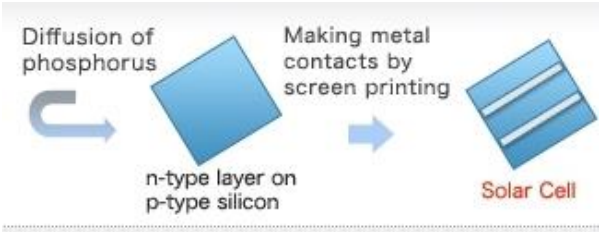
Wafering

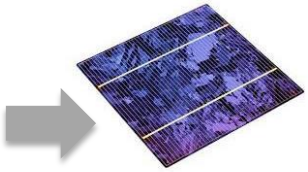


Multi

Mono

Solar Cell

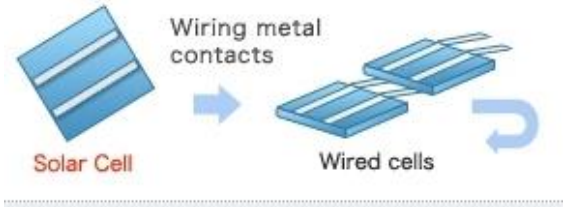


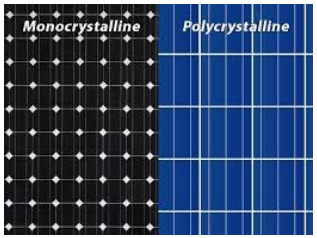


Poly-Crystalline Solar Cell

Mono-Crystalline Solar Cell

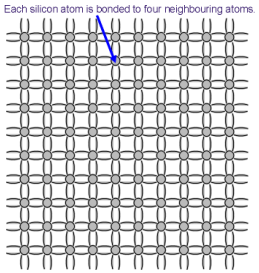
Solar Module



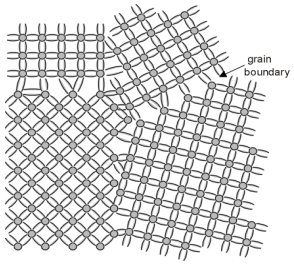


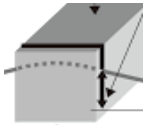
c-Si Wafer based Solar Cells

C-Si Solar Cells



Pseudo Square





Full Square

p-type

-Al-BSF

-Al-LBSF / PERC

-Bi-facial

n-type

-Bifacial

-All Back Contact/ Interdigitated BC (ABC or IBC)

p-type

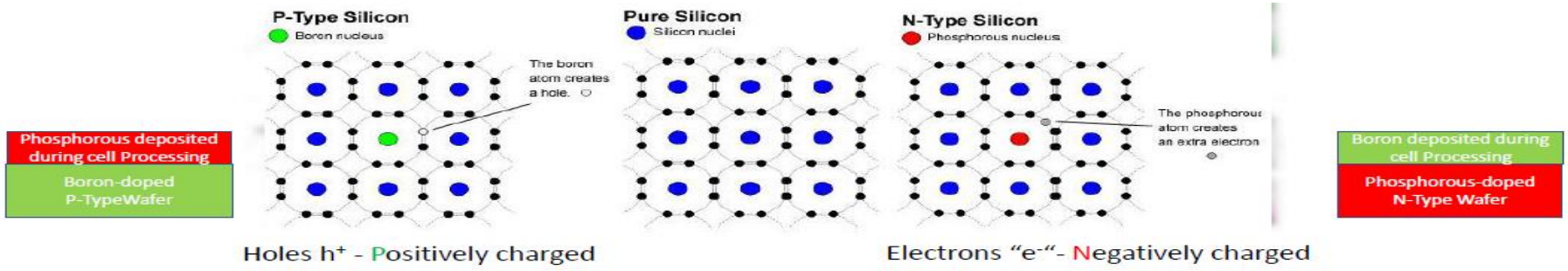
-Al-BSF

-Al-LBSF / PERC

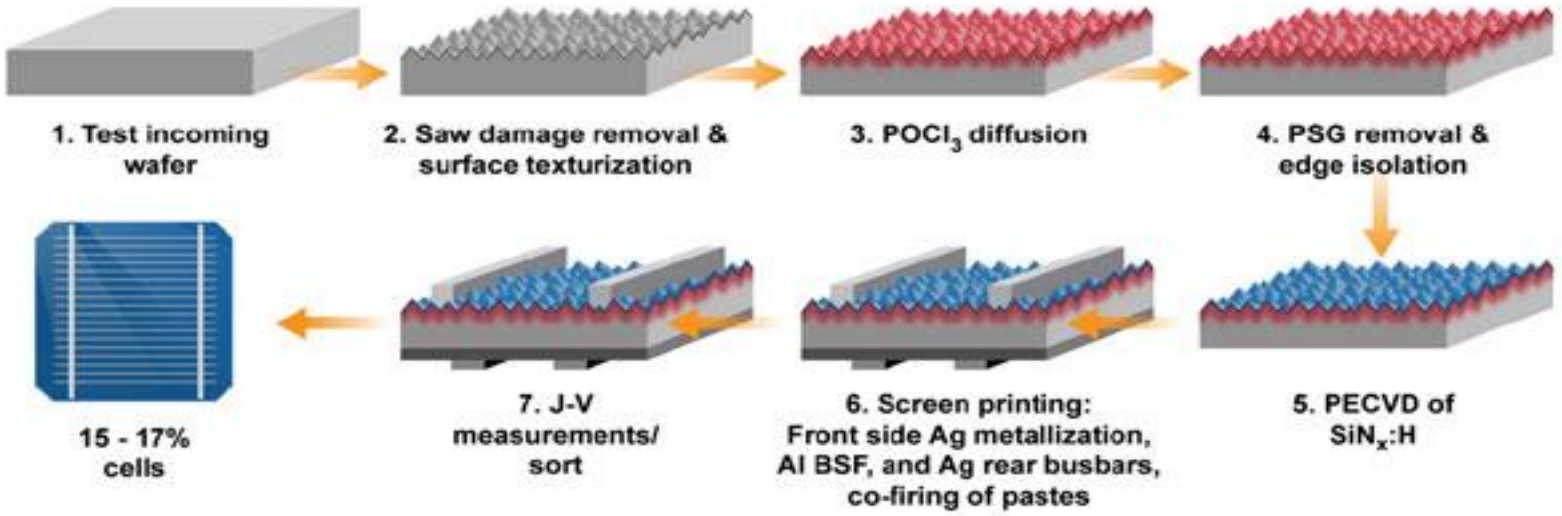
-Bi-facial

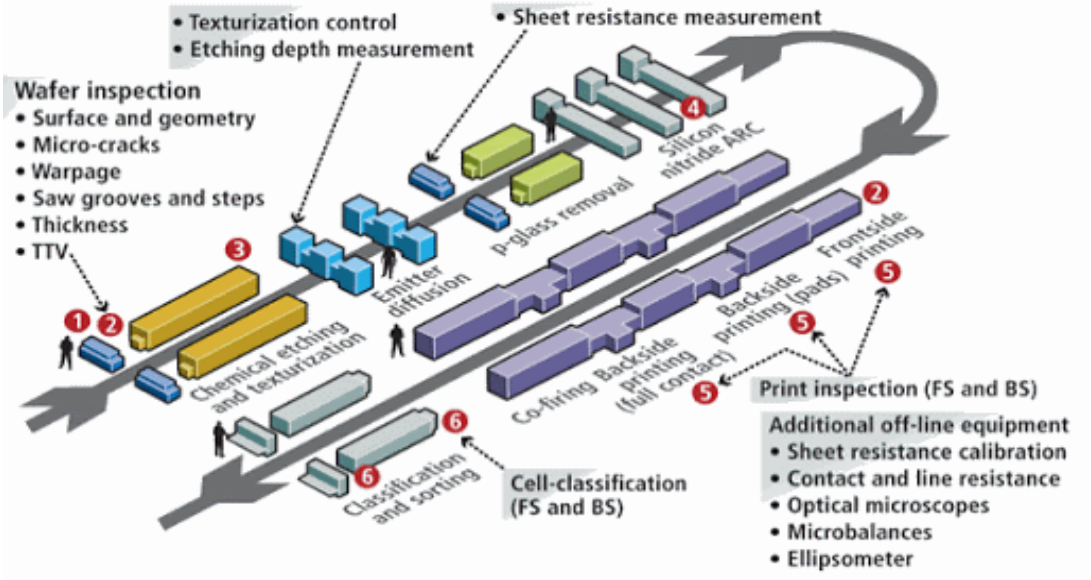
More than 90% of the PV Module market today is P-type

Al-BSF: Aluminium Back Surface Field, **LBSF, L:** Localised
PERC: Passivated Emitter Rear Contact



c-Si Solar Cell Manufacturing





c-Si PERC Solar Cell

Passive Emitter Rear Cell (PERC) Structure

Recombination of e- and h+ neutralizes them and thus reduces cell efficiency

Defects in Solar cells act as Recombination Centers

In PERC Cells, Hydrogen-rich dielectric layer is added to the rear of the cell for Defect Passivation ("Healing the defects") to decrease recombination and to improve Internal Reflection – "Rear Passivation Stack"

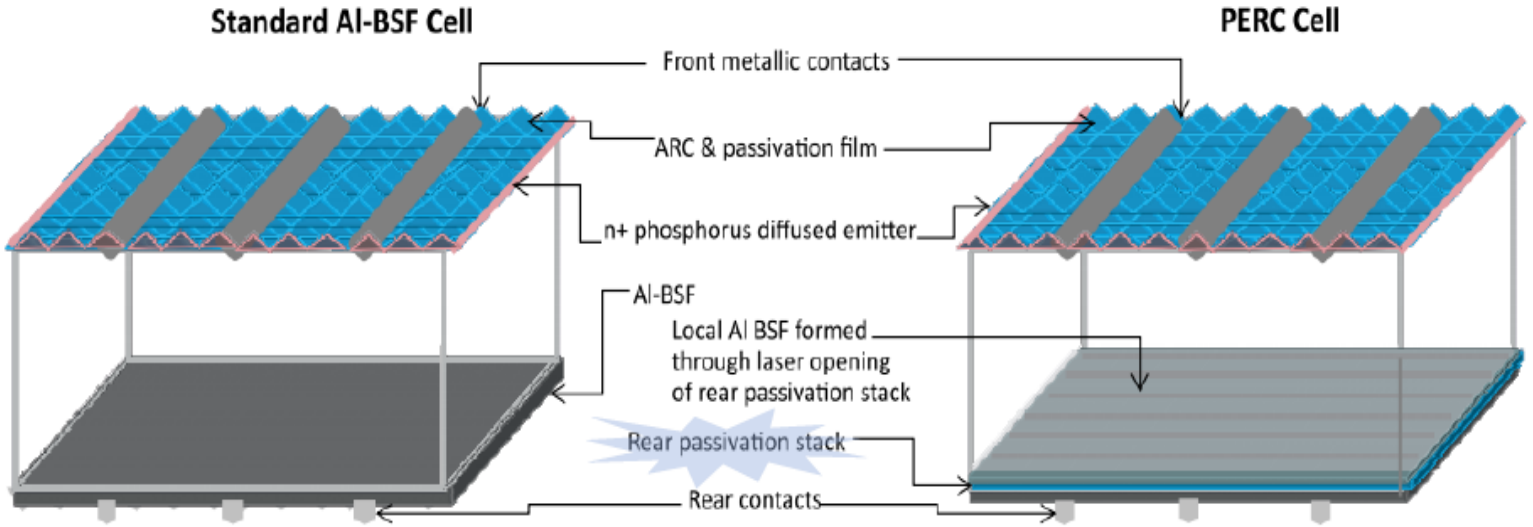
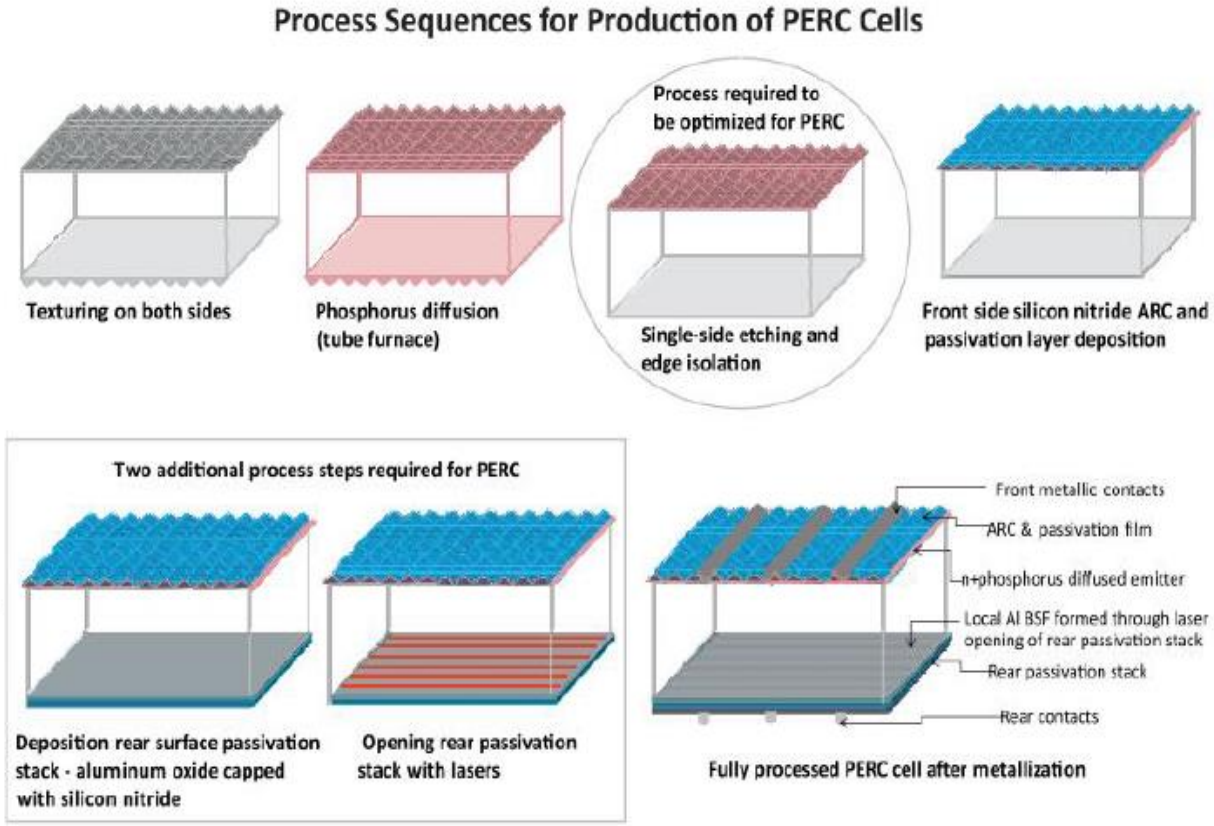


Image: Taiyang News

c-Si PERC Solar Cell

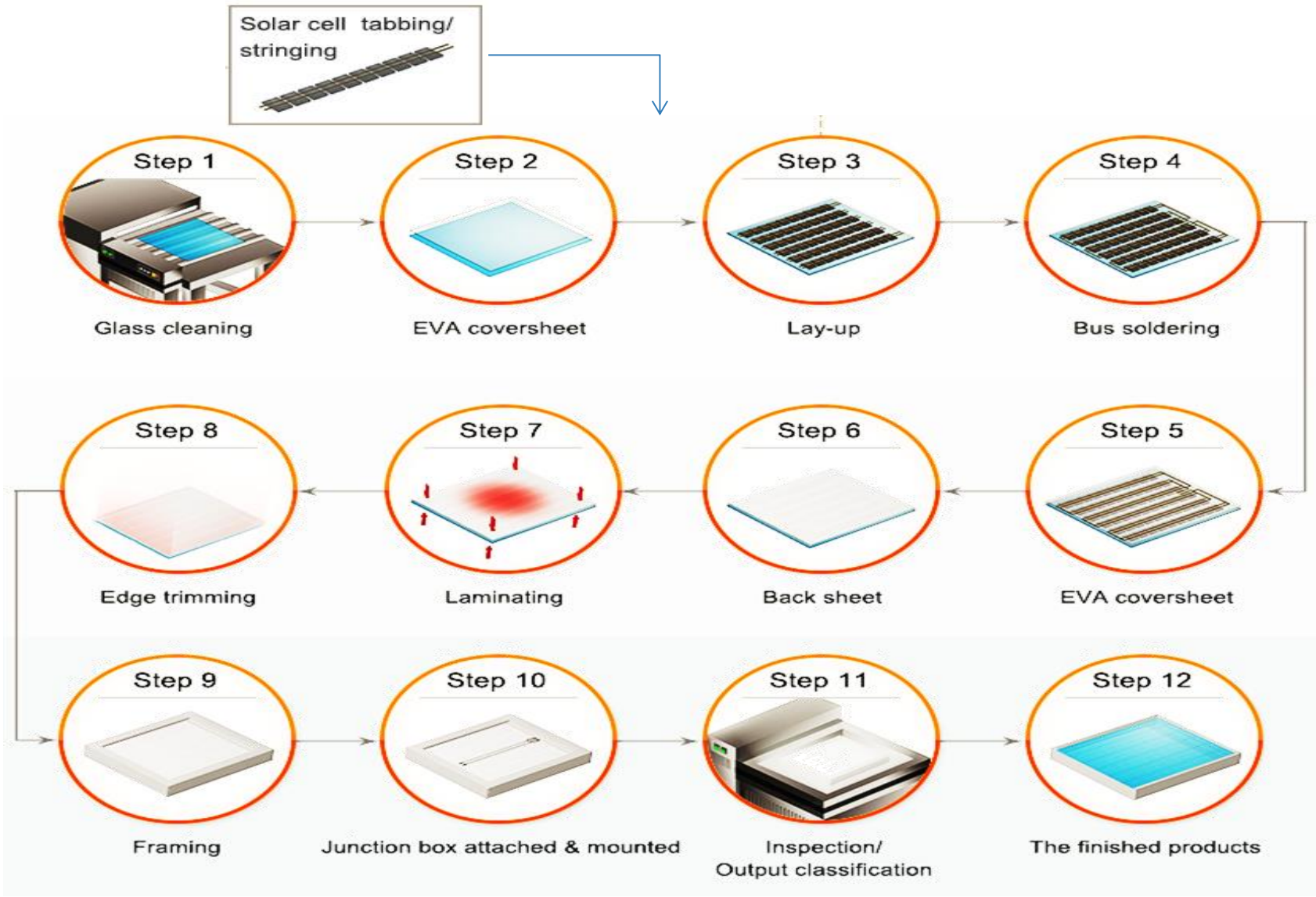
Why did PERC Gain Immense Popularity?

By adding just 2 Process Steps to a traditional cell process, an absolute 1% increase in Efficiency was made possible!



Easy upgrade: Changing a standard silicon cell line to PERC technology requires two pieces of additional equipment - devices for rear passivation and laser structuring, as shown in this process flowchart.

Module Manufacturing Process



Modules Technology Difference

Sl No	Mono C-Si Module	Multi C- Si Module	Thin film Module
1	Most efficient 21-23%	Less efficient 17 - 20%	Least efficient 11 – 15%
2	Manufactured by single Si crystal	Manufactured by fusing different crystals of Si	Manufactured by depositing one or more layers of PV material on Substrate
3	Best at standard temperature	Best at moderately high temperatures	Best at high temperatures
4	Least area for a given power	Less area for a given power	Requires large area for a given power
5	Large amount of Si hence, high embodied energy	Large amount of Si hence, high embodied energy	Low amount of Si used hence, low embodied energy
6	Performance degrades in low-sunlight conditions	Performance degrades in low-sunlight conditions	Performance less effected by low-sunlight conditions
7	Most expensive	Least expensive	Less expensive

Module Design Parameter

Design Parameter

- Cell Information : Type, FC/HC, Dimension, no of Cells/per string, no. of String.
- String Information : Gap between Cell /String, Cell to Frame Bottom/Top/Left/Right.
- Module Overall Dimension : AxBxC in mm, Weight & Matrix.
- Al.Frame : MOC, Type, Color, Anodizing thk-um, Mounting hole, dimension, Grounding hole, Drainage hole.
- Solar Glass/Encapsulant/Backsheet : ARC, Thk, Type
- Ribbon/Busbars : Ribbon/Busbar width, thk, No. of Fingers per Cell, MOC.
- Junction Box/Cable : JB MOC, dimension, No. of Diodes, Potting, Cable lg, cross section -mm2, Type of Cable connector.
- Sticker : Size, Power bin class, Electrical parameter

Electrical Specifications

- Electrical Testing : Pmax (W), Vmp(V), Imp(A) Voc(V), Isc(A), Module Eff(%)
- Temperatur Coefficients : Pmax (%/K), Voc (%/K), Isc (%/K), Power Tolerance(%)
- Module Ratings : Max System Voltage(VDC), Series Fuse rating (A), Operating Temp(Deg C), NOCT (Deg C), System Voltage (VDC)
- Environmental Testing : Operating Temp, Wind Load, Hail resistance, Humidity Freeze, Damp heat, Snow Load

Module Inspection

Visual Inspection

- Cell Inspection : Edge Chipping, V chip, Crack, Finger interruptions.
- Lamination Visual Inspection : Air bubble, De-lamination, SL.No, Bar Code, Foreign partical inclusion, Glass Scratches etc)
- Cell Matrix Inspection : Cell to Cell / String to string gap, Solder ribbon / String alignment, Interconnect misalignment, Cell edge to Top/Bottom/Sides)
- Al. Frame Inspection : Scratches, Dent /Spot on Frame, Corner Gaps, Frame misalignment.
- Module Backside Inspection : JB alignment, BS scratches, Cable connection, Sticker Power series/alignment, Glue dispensing.

Electroluminescence(EL) : To control the type of Cell defects such as micro-cracks, cracks, broken fingers, dead area/cell, Soldering defect Black edges etc. Following are the type of defects;

- Estimated Module defective active area
- Maximum Cell level defective area
- Presence of Cell with multiple cracks & micro-cracks.
- Number of cracks & micro-cracks in Module classified in the following categories;
- Cross cracks
- Perpendicular / Parallel to busbars
- Cracks with other directions
- Grid finger defects
- Presence of inactive cells
- Presence of soldering defects
- Presence of Module contact defects

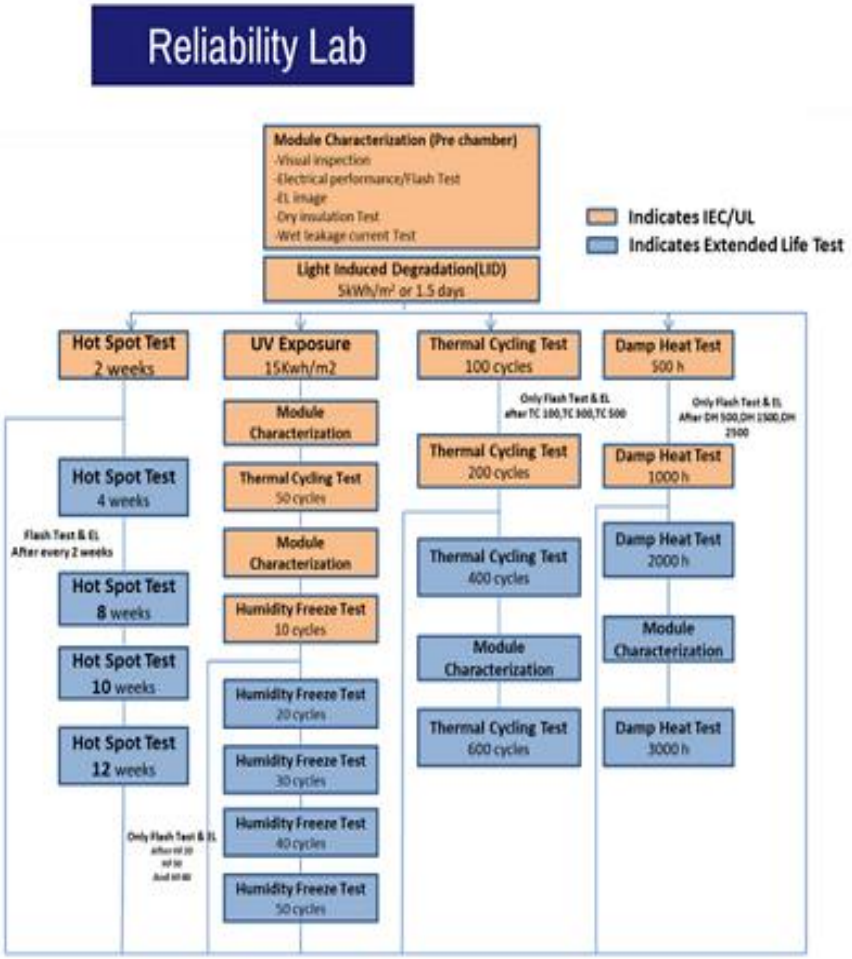
Module Inspection

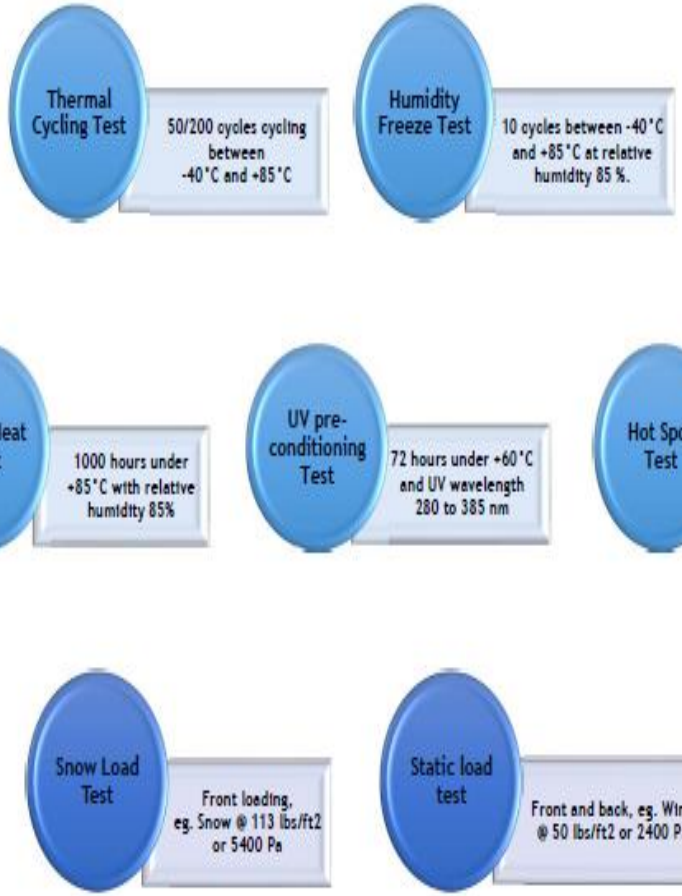
Module Power measurement Protocol

The purpose of this process is to verify the peak power (Wp) of the Modules.;

- Power measurement is to be performed with AAA+ pulsed solar simulator in a dark chamber designed to reduce the impact of indirect light.
- The reference irradiance is to calibrate against the Gold reference Module (issued & calibrated) by reputed 3rd party IEC approved lab with measurement uncertainty, under Standard Test Condition (STC as detailed in IEC 61215 i.e 1000W/m2, 25 Deg Centigrade and AM 1.5).
- The temperature of the Gold Reference Module is to be controlled within ±2 Dec C for avoidance of doubt, the practical figure shall be as per the statement of third party.
- Flash Test data analysis has to be with reference to :
  - Module Serial number
  - Name Plate Power
  - Power measured at manufacturing location
  - Electrical parameters such as Voc, Isc, Impp, Pmpp, Efficiency, FF etc.

Module Reliability – Test Protocol





India's PV Manufacturing Capacity and Product Mix

Following is the Module manufacturing statistics of India;

- India's total Annual Installed Module Capacity **9.9 GW**
- Total Module manufacturers **160**
- Top 5 Module manufacturers contribute almost **50% of total cap**

RenewSys is among the Top 4 Module manufacturers in India

Product Mix : Indian manufacturers are geared up to supply higher output Modules of 335/340Wp in Multi, 375/380Wp in Mono PERC and 390/400Wp in HC Mono Modules.with use of max 158.75 Sqmm Solar Cells.

Following is the Solar Cell manufacturing statistics of India;

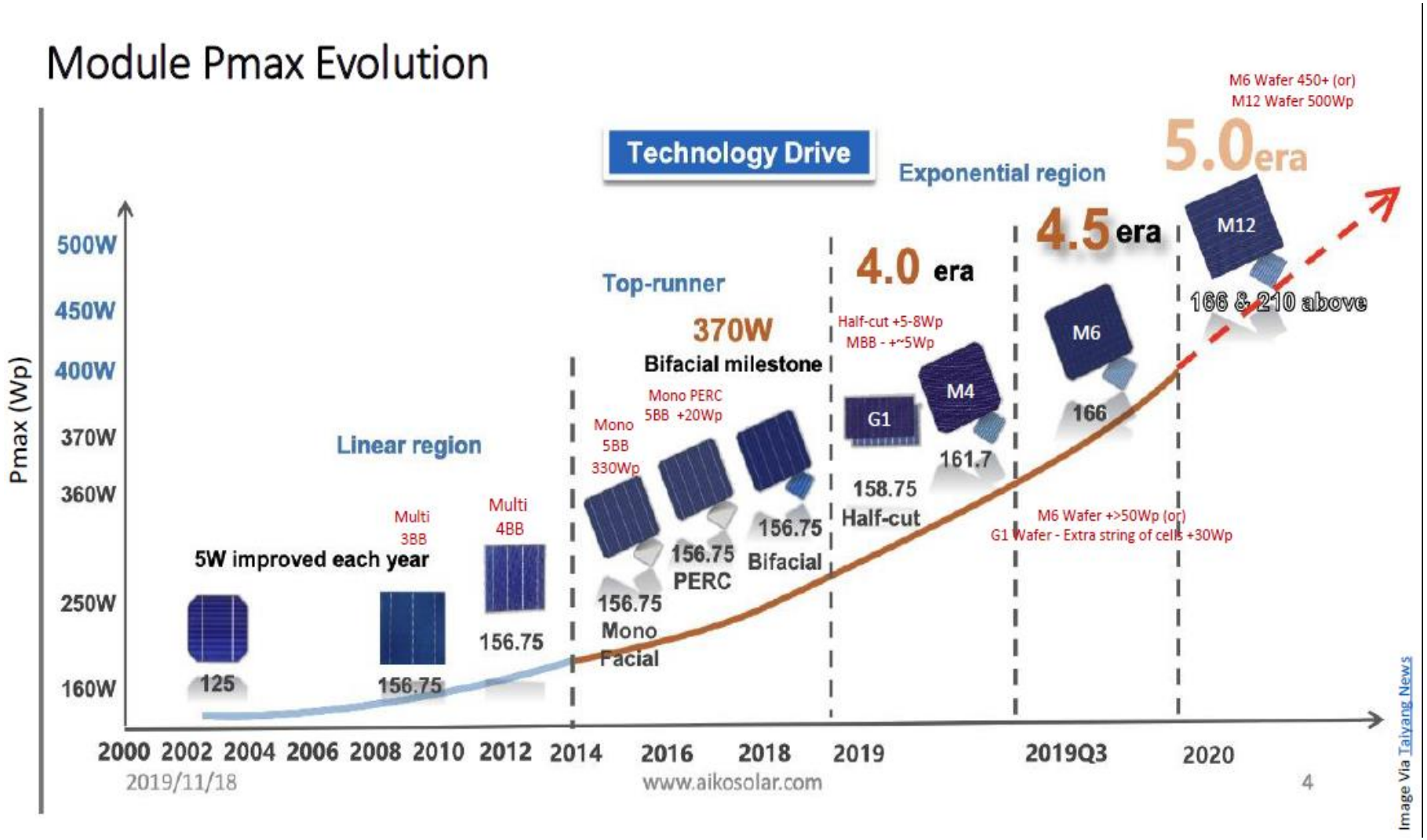
- India's total Annual Installed Solar Cell Capacity **3.0 GW**
- Total Cell manufacturers **14**
- Top 5 Cell manufacturers contribute almost **78% of total cap**

RenewSys is among the Top 7 Solar Cell manufacturers in India

Product Mix : Indian manufacturers are geared up to supply upto 19% of Multi c-Si Solar Cell and upto 21.4% Mono PERC

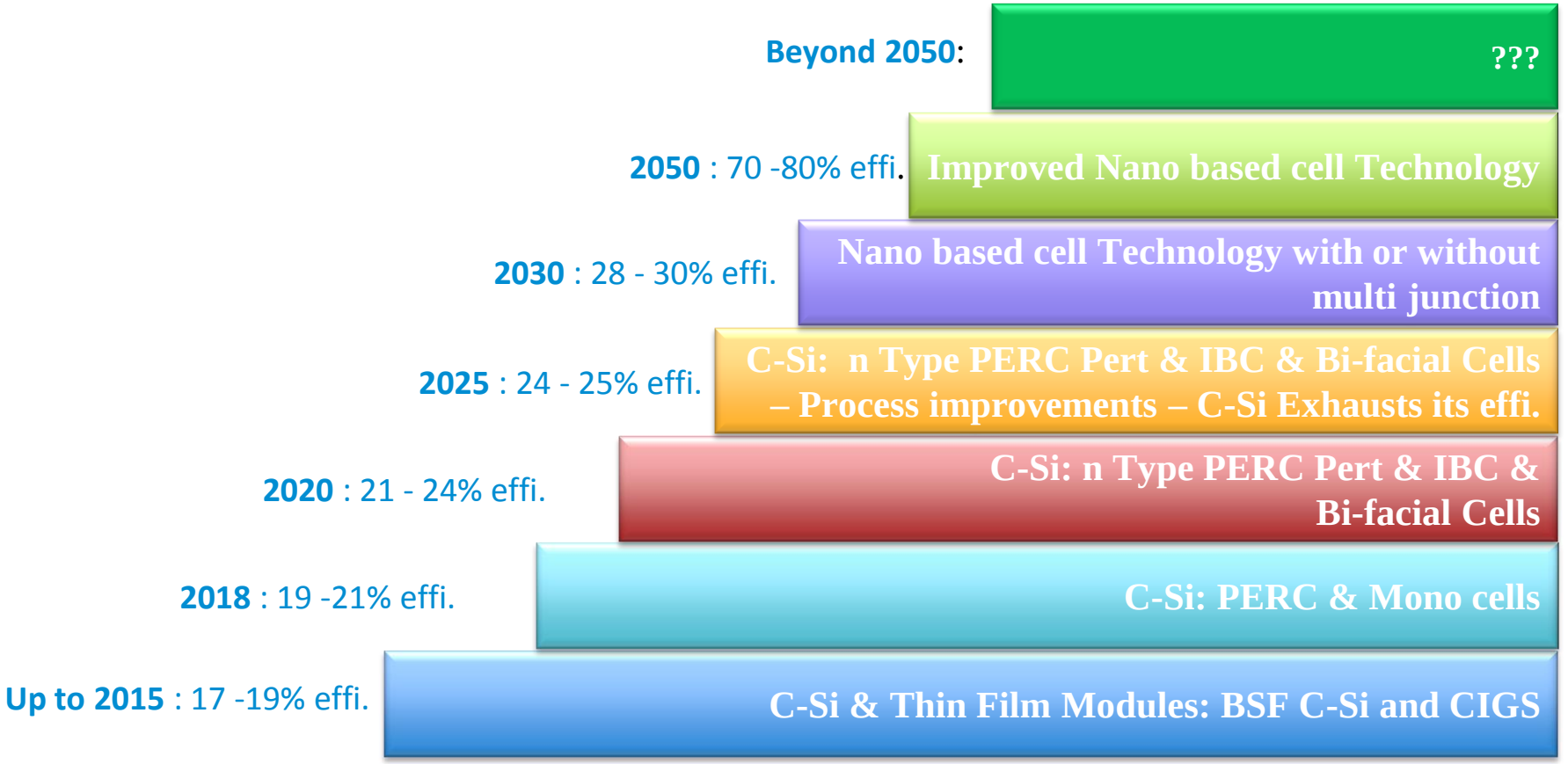
Existing Module Technologies & Efficiencies

Module Technology Evolution

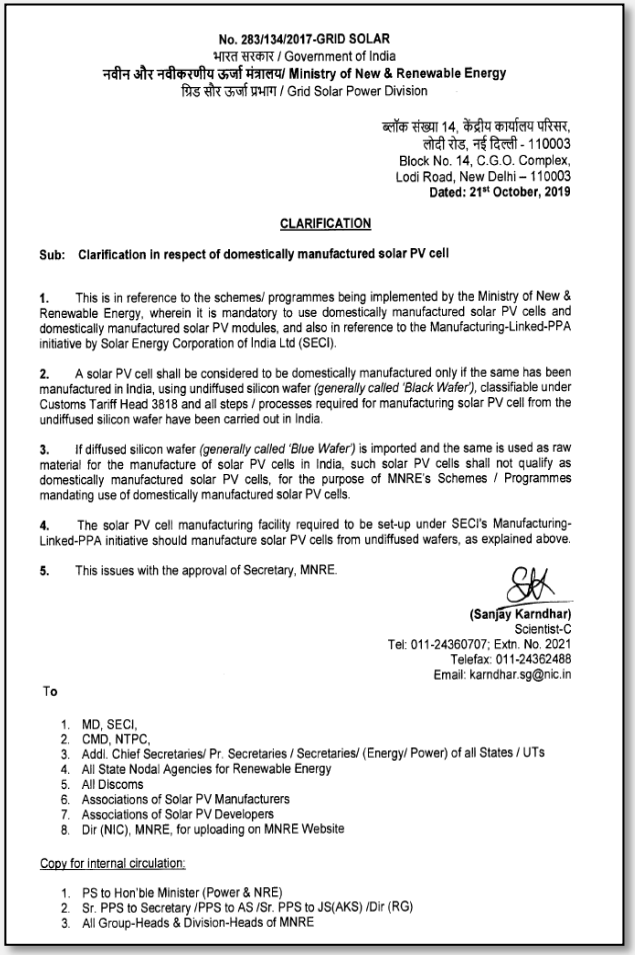


Module Technology Roadmap
Major Market Scenario

- Silicon Cell tech limits its efficiency at around 25%
- We still need a super tech to harvest remaining 75% which is currently getting wasted



DCR – Modules, Cells & Compliance



No. 283/134/2017-GRID SOLAR
भारत सरकार / Government of India
नवीन और नवीकरणीय ऊर्जा मंत्रालय/ Ministry of New & Renewable Energy
ग्रिड सौर ऊर्जा प्रभाग / Grid Solar Power Division

ब्लॉक संख्या 14, केंद्रीय कार्यालय परिसर,
लोदी रोड, नई दिल्ली - 110003
Block No. 14, C.G.O. Complex,
Lodi Road, New Delhi – 110003
Dated: 21st October, 2019

CLARIFICATION

Sub: Clarification in respect of domestically manufactured solar PV cell

1. This is in reference to the schemes/ programmes being implemented by the Ministry of New & Renewable Energy, wherein it is mandatory to use domestically manufactured solar PV cells and domestically manufactured solar PV modules, and also in reference to the Manufacturing-Linked-PPA initiative by Solar Energy Corporation of India Ltd (SECI).

2. A solar PV cell shall be considered to be domestically manufactured only if the same has been manufactured in India, using undiffused silicon wafer *(generally called 'Black Wafer')*, classifiable under Customs Tariff Head 3818 and all steps / processes required for manufacturing solar PV cell from the undiffused silicon wafer have been carried out in India.

3. If diffused silicon wafer *(generally called 'Blue Wafer')* is imported and the same is used as raw material for the manufacture of solar PV cells in India, such solar PV cells shall not qualify as domestically manufactured solar PV cells, for the purpose of MNRE's Schemes / Programmes mandating use of domestically manufactured solar PV cells.

4. The solar PV cell manufacturing facility required to be set-up under SECI's Manufacturing-Linked-PPA initiative should manufacture solar PV cells from undiffused wafers, as explained above.

5. This issues with the approval of Secretary, MNRE.

(Sanjay Karndhar)
Scientist-C
Tel: 011-24360707; Extn. No. 2021
Telefax: 011-24362488
Email: karndhar.sg@nic.in

To

1. MD, SECI,
2. CMD, NTPC,
3. Addl. Chief Secretaries/ Pr. Secretaries / Secretaries/ (Energy/ Power) of all States / UTs
4. All State Nodal Agencies for Renewable Energy
5. All Discoms
6. Associations of Solar PV Manufacturers
7. Associations of Solar PV Developers
8. Dir (NIC), MNRE, for uploading on MNRE Website

Copy for internal circulation:

1. PS to Hon'ble Minister (Power & NRE)
2. Sr. PPS to Secretary /PPS to AS /Sr. PPS to JS(AKS) /Dir (RG)
3. All Group-Heads & Division-Heads of MNRE

Link to Notification

1. Cells to be made using un-diffused silicon wafer - generally called Black Wafer

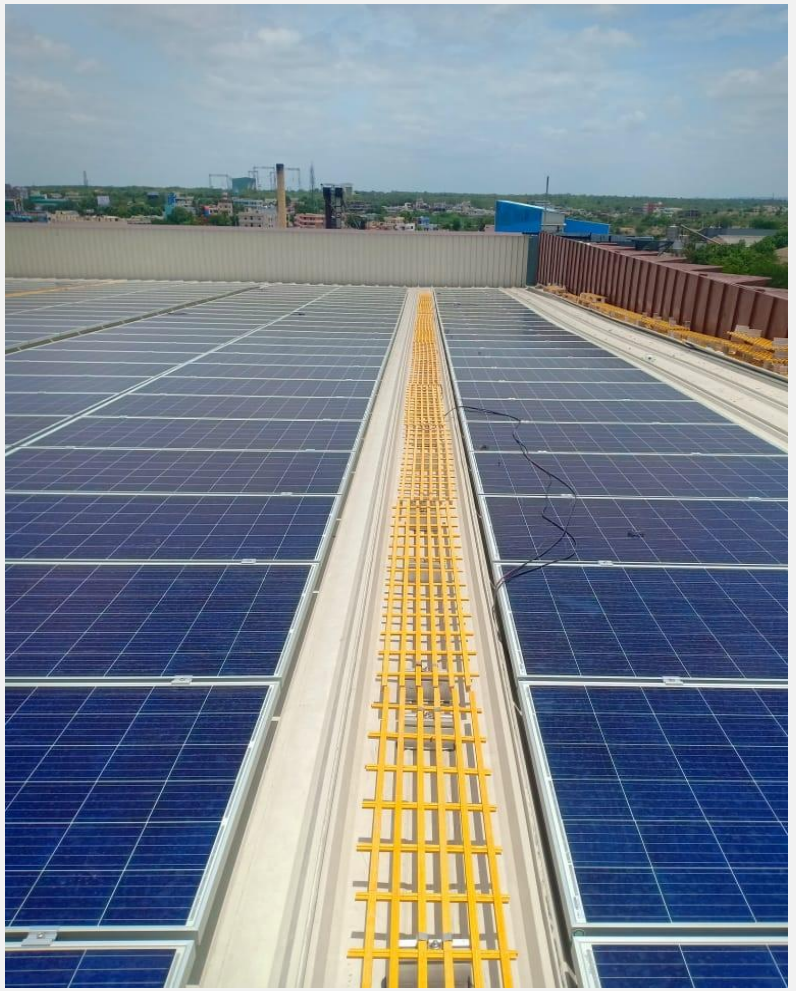
2. Cells made using diffused silicon wafers (Blue Wafers) do not qualify for DCR

DCR Certifications

Rooftop Tender Requirements

Solar PV Modules/ Panels
IEC 61215/ IS 14286
IEC 61701
IEC 61853- Part 1/ IS 16170: Part 1
IEC 62716
IEC 61730-1,2

Big Basket , Hyd.



DCR Compliances - Traceability

Following are the Traceability measures;

- **Compliance to Certification (BIS & IEC)** : Strict compliance to BIS and IEC Certification including the traceability for the use of approved Bill of Material (B.O.M) is mandatory requirement. Following Certifications to be checked and verified;

  IS-14286, IS/IEC-61730:Part-1&2, IEC-61701, IEC-62804, IEC-62716, IEC-61853

- **Use of Approved B.O.M and verification through CDF including following**:

  Approved Indian Make Cells of 5BB,
  Approved Make of min 3 layer, ≥300um Backsheet
  Solar Glass of min 3.2mm thickness
  RFID tag including details as per MNRE requirement
  Front & Back Label as per MNRE requirement

- **Compliance to Documentation** : Following documents along with Invoice & Packing List to be submitted, giving reference of Modules used for the Project ;

  FTR (Flash Test Report)
  IV Curves of Individual Modules
  Self -Declaration for use of Domestic Cells and Modules giving the customer order and Project Tender reference
  Mass Balance Sheet can to be checked as Solar Cell and Module Manufacturer's end, covering the Input and output norms.

- **Pre-despatch Inspection (PDI) for Modules** : Sampling and PDI to be carried-out for Solar Modules at manufacturers plant and only after issual of Inspection report covering Visual, EL, Flash Test, hi-pot tests, the modules should be allowed to despatch.

Commercial Outlook…

- India works on ‘Cost-plus’ model and has disadvantages of - Higher power cost (cell process - power intensive), Non existent Supply Value Chain, Lack of Economies of Scale, Higher cost of Interest.
- Only by having a superior ecosystem in India, can bring down DCR cost further. This can only happen if all stakeholders support the DCR policy
- DCR module pricing is same across all formats irrespective of the system award price listed in the table below.
- DCR price variation statewise;

Sizing	PGVCL	TSREDCO	UPNEDA
1 to 10kW	46000-43000	54000	38000
>10 Kw	38000	52000	32000

- Current Scenario wherein currency has fluctuated almost by 8% in last 1 month and R.M prices and Logistics cost have gone up steeply. In view of same, the Module price will have the impact accordingly.

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Thank You!