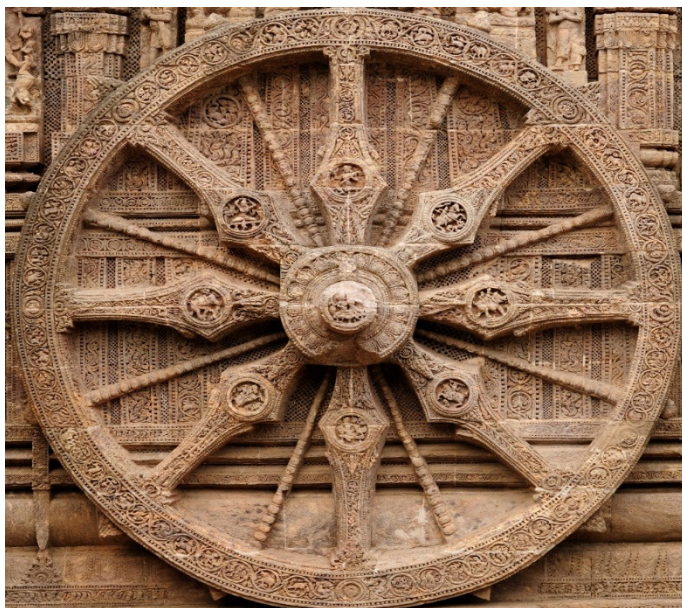


# An Overview of Rooftop Solar Energy Program of SECI



Chariot Wheel – Konark Sun Temple, Odisha  
Konark Sun Temple is a 13<sup>th</sup> Century Sun Temple



200 kWp Rooftop Grid Connected SPV Power Plant  
Nirman Bhawan, New Delhi

**Solar Energy Corporation of India Ltd.**

(A Government of India Enterprise)

1<sup>st</sup> Floor, Religare Building

D-3 District Centre, Saket, New Delhi-110017

## About SECI

- Foundation day: 20<sup>th</sup> September 2011
- Authorized capital: Rs. 2000 Cr
- Paid-up capital: Rs. 204 crores
- Net Profit in FY 15-16: ~ Rs. 25 crores
- SECI has registered as “**Section 3**” company under Companies Act - 2013 – to be renamed as “Renewable Energy Corporation of India (RECI)”



## SECI's Activities

### Solar project development

- Setting large scale/rooftop solar projects

### VGF schemes for large ground mounted SPV projects

- 750 MW – executed
- 2000 MW and 5000 MW schemes in tendering stage

### Subsidy/Incentive Schemes for Rooftop SPV projects

- 54 MW – executed, 66 MW – under implementation
- 500 MW scheme in award state and 1000 MW schemes in tendering stage

### Solar Parks

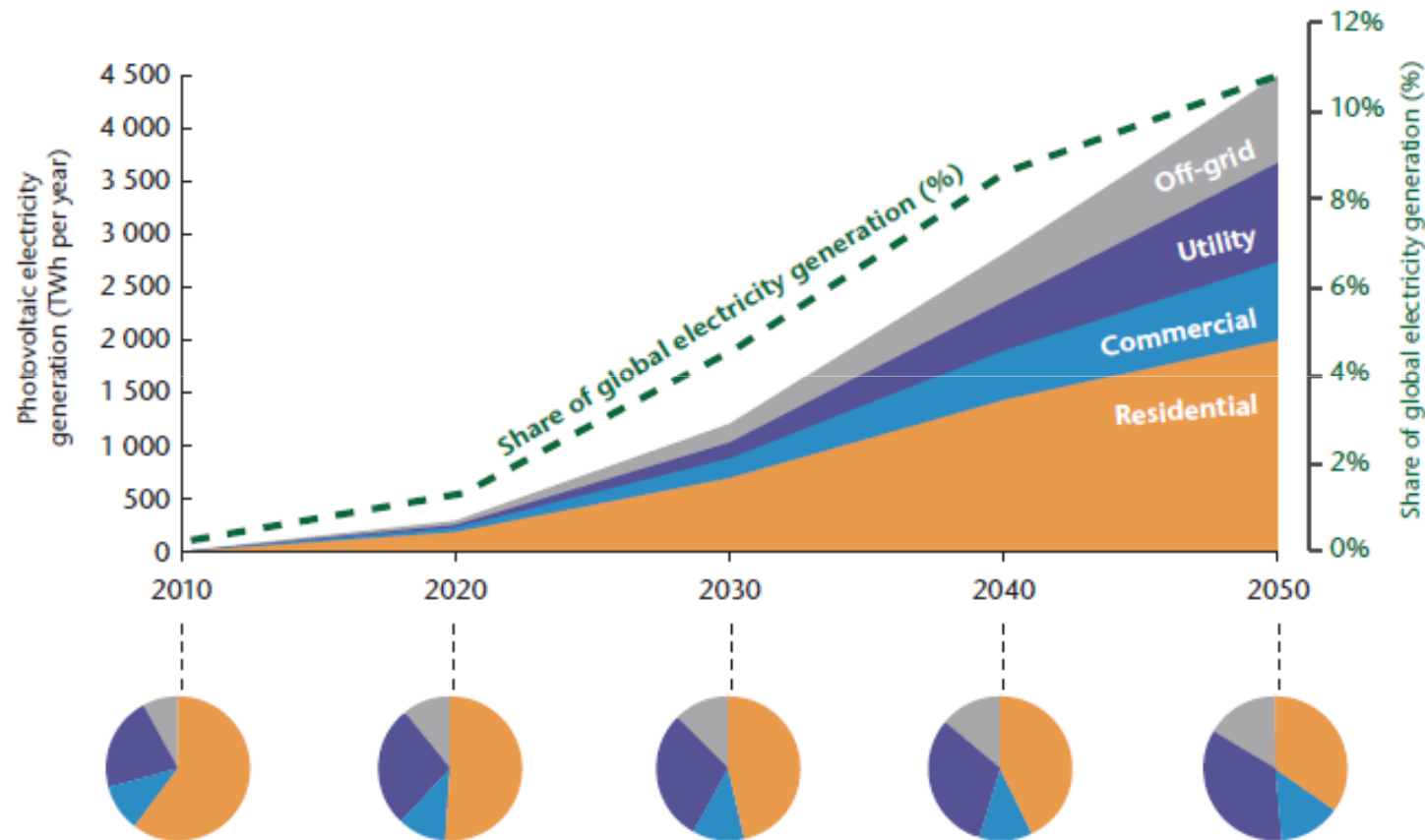
- Setting up 6 solar parks as JV partner

### Power Trading

- Large-scale interstate trading of Solar power for the first time
- More than 1000 Million Units traded



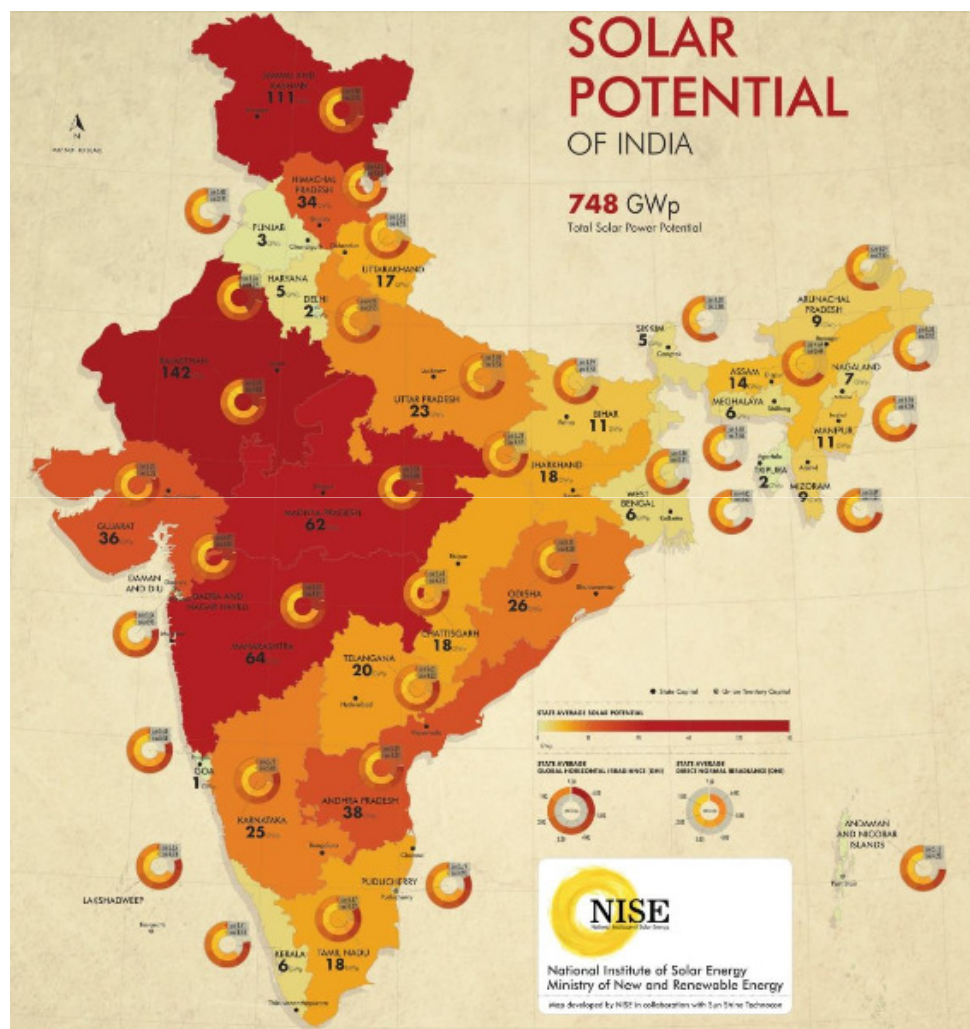
# Global PV installations projections



Residential sector would be the major part along with large scale utility power plants

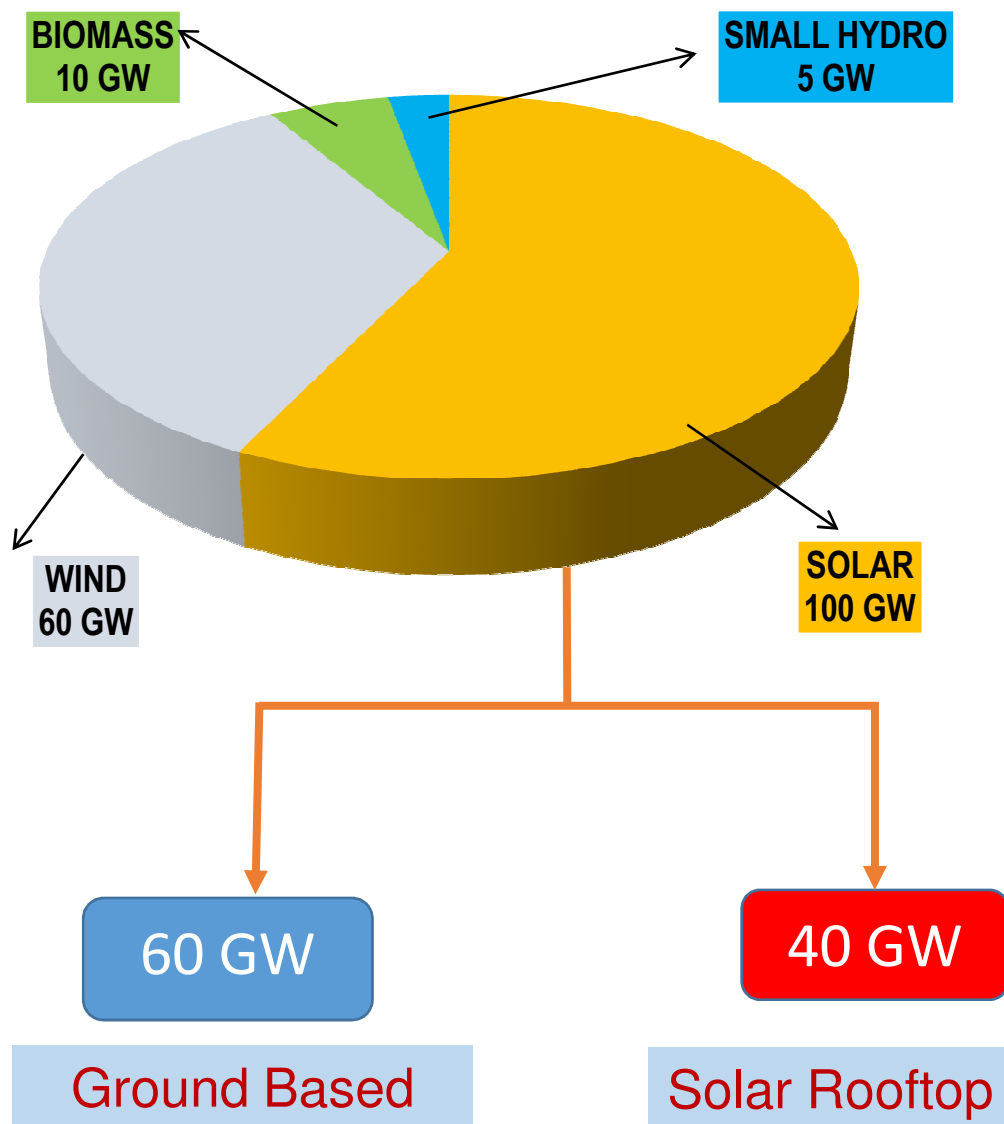


# Solar Potential in India

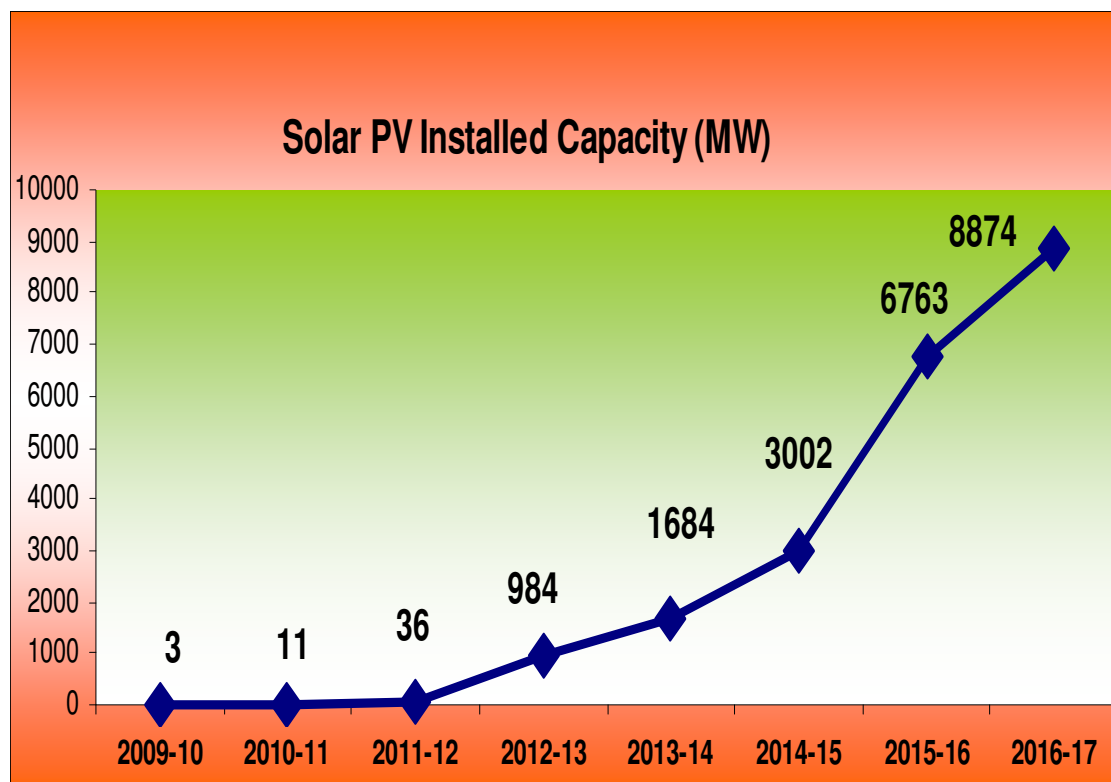


State/UT	Potential (GW)	%
Rajasthan	142.31	19.00%
J & K	111.05	14.83%
Maharashtra	64.32	8.59%
Madhya Pradesh	61.66	8.23%
Andhra Pradesh	38.44	5.13%
Gujarat	35.77	4.78%
Himachal Pradesh	33.84	4.52%
Odisha	25.78	3.44%
Karnataka	24.7	3.30%
Uttar Pradesh	22.83	3.05%
Telangana	20.41	2.73%
Others	167.88	22.41%
<b>TOTAL</b>	<b>748.99</b>	<b>100.00%</b>

# Renewable Energy Targets :175 GW by 2022



# Growing Solar Installations in India



3018 MW Solar Capacity was added in 2015-16 – 116% higher than the target

State/UT	(MW)	%
Tamil Nadu	1555.41	17.82%
Rajasthan	1301.16	14.91%
Gujarat	1138.19	13.04%
Andhra Pradesh	968.05	11.09%
Telangana	963.79	11.04%
Madhya Pradesh	811.38	9.30%
Punjab	571.2	6.54%
Maharashtra	386.06	4.42%
Karnataka	340.08	3.90%
Uttar Pradesh	143.5	1.64%
Chhattisgarh	128.56	1.47%
Others	420.24	4.82%
<b>TOTAL</b>	<b>8727.62</b>	<b>100.00%</b>

Source: MNRE, 30/11/16

## India's commitment in CoP 21 at Paris: An Act of Faith

India's Intended Nationally Determined Contribution (INDC):

- To lower the emissions intensity of GDP by 33% to 35% by 2030 below 2005 levels
- To increase share of Renewable energy generation capacity to 40% of installed energy capacity by 2030

# Progress Status of Rooftop Solar in India



State/UT	(MW)	%
<b>Tamil Nadu</b>	<b>132</b>	<b>12.94%</b>
Gujarat	69	6.76%
Maharashtra	89	8.73%
Punjab	55	5.39%
Karnataka	51	5.00%
Rajasthan	46	4.51%
Uttar Pradesh	33	3.24%
Telangana	27	2.65%
Andhra Pradesh	32	3.14%
Haryana	57	5.59%
Delhi	35	3.43%
Chhattisgarh	16	1.57%
Others	378	37.06%
<b>Total</b>	<b>1020</b>	<b>100.00%</b>



Source: Bridge to India, as on 30<sup>th</sup> September 2016



# SECI's Grid Connected Rooftop Programme



80 MWp (Yr 2013 -14)

50 MWp for CPWD (Yr 2015-16)

73 MWp scheme for Warehouses  
(Year 2015-16)

500 MWp scheme with CFA (Year 2016)

1000 MWp scheme incentive scheme,  
09/12/2016

Many More schemes are being planned



# Implementation Model

- Projects are implemented under two broad business models
  - I. CAPEX (Ownership Model) – bids invited on project cost
  - II. RESCO (PPA Model) – bids invited on tariff
- Against total 554 MWp rooftop capacity allocated:
  - ~400 MWp under Capex Model
  - ~150 MWp under RESCO



State wise Sanctioned capacity		
Sl. No.	State	Capacity (MWp)
1	A&N	1.0
2	Andhra Pradesh	1.5
3	Bihar	0.4
4	Chattishgarh	0.8
<b>5</b>	<b>Delhi</b>	<b>9.6</b>
6	Gujarat	4.3
7	Haryana	5.6
8	J&K	0.1
9	Jharkhand	1.3
<b>10</b>	<b>Karnataka</b>	<b>5.8</b>
11	Madhya Pradesh	0.8
<b>12</b>	<b>Maharashtra</b>	<b>10.2</b>
13	Odisha	1.3
14	Punjab	3.0
15	Rajasthan	3.3
<b>16</b>	<b>Tamil Nadu</b>	<b>14.7</b>
17	Telangana	5.0
<b>18</b>	<b>Uttar Pradesh</b>	<b>9.0</b>
19	Uttarakhand	0.4
20	West Bengal	2.8
<b>Total</b>		<b>80.8</b>

# Rapid Rooftop SPV Growth across the Country

Implementing Rooftop  
projects with subsidy  
from MNRE

Upto 500kW capacity  
projects being set up in  
select cities

**Phase I:** 5.5 MW (4 cities)

**Phase II:** 11.3 MW (6 cities)

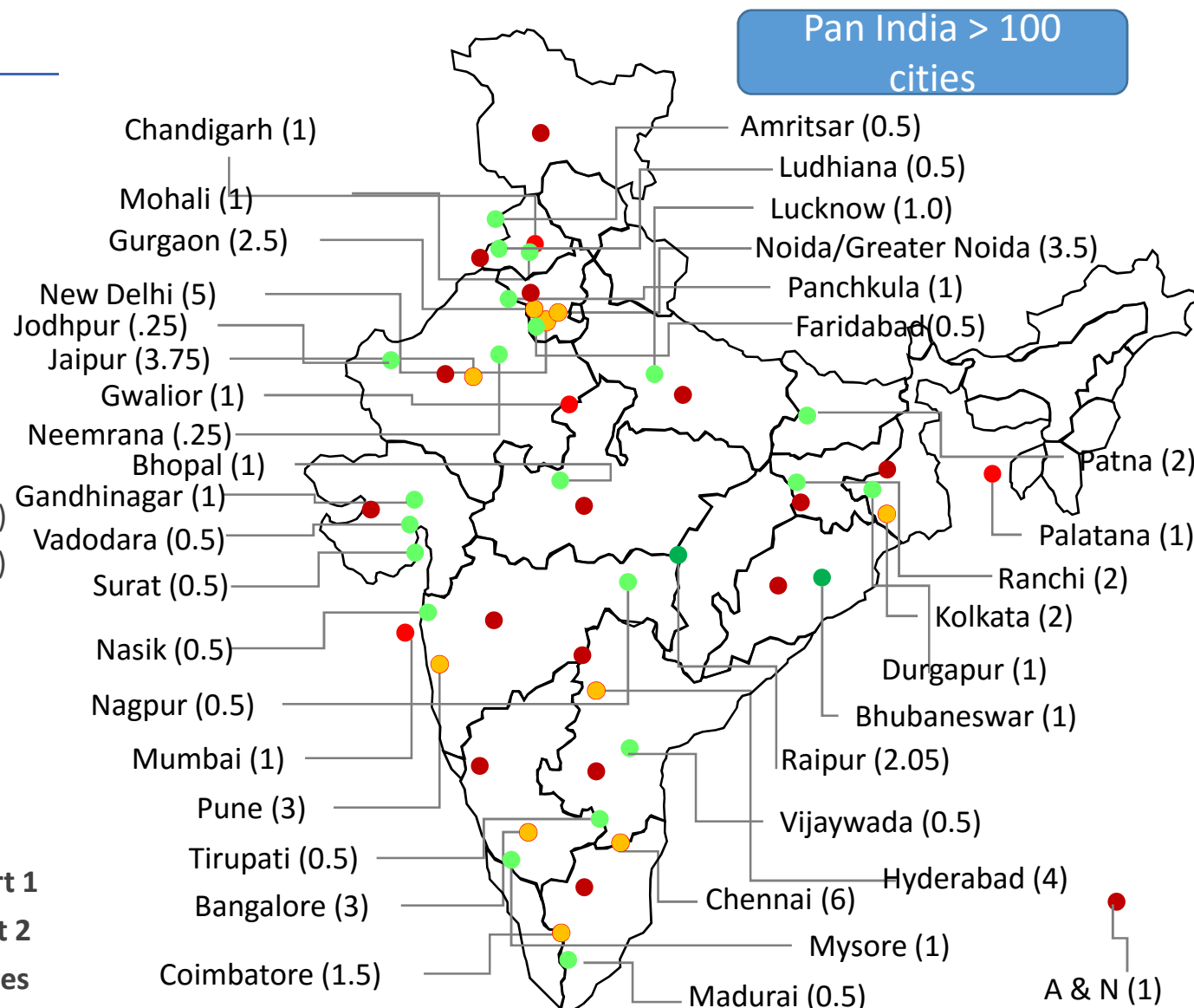
**Phase III:** 10 MW (9 cities)

**Phase IV -1:** 32.5 MW (29 cities)

**Phase IV -2:** 24 MW (17 States)

## Legend

- Phase I
- Phase II
- Phase III
- Phase IV – Part 1
- Phase IV –Part 2
- Multiple phases



# Achievements so far...

- Rooftop programme expanded from Tier I to Tier III cities: covering 20 States/UTs, about 100 cities
- Benchmark cost reduced from Rs. 130/Wp to Rs. 75/Wp
- (554) 122 + 432 MWp capacity allocated among 165 (43 + 122) successful bidders covering 20 States including Andaman & Nicobar Islands of India
- More than 80 MWp (~450 nos. projects) rooftop capacity sanctioned so far
- 54 MWp commissioned
- Rs. 70 Cr CFA released to the project developers (inter-alia means more than Rs. 300 Cr. investment in the rooftop segment).
- Segment wise implementation
  - Around 40%- Industrial
  - Around 35% Govt.
  - Around 17% Institutional

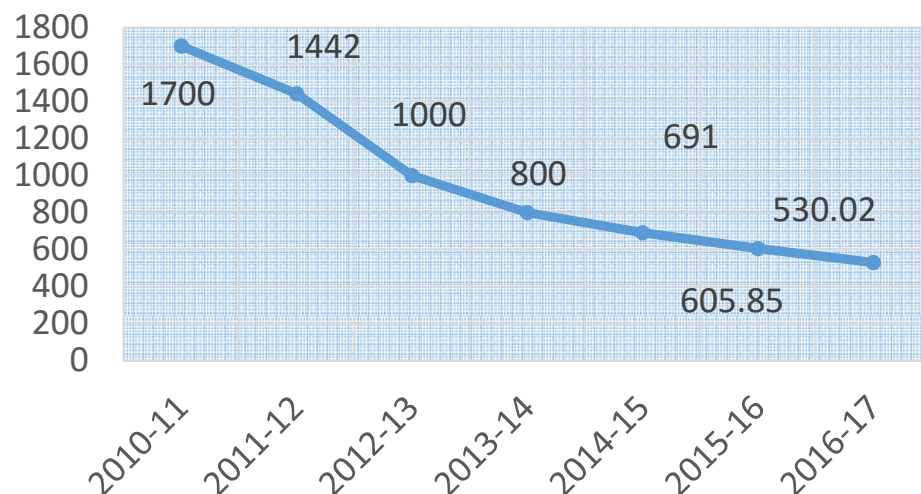




# Solar PV: Getting More Affordable



**CERC India Benchmark Cost for Solar PV**  
(₹ Hundred Thousand/MW)

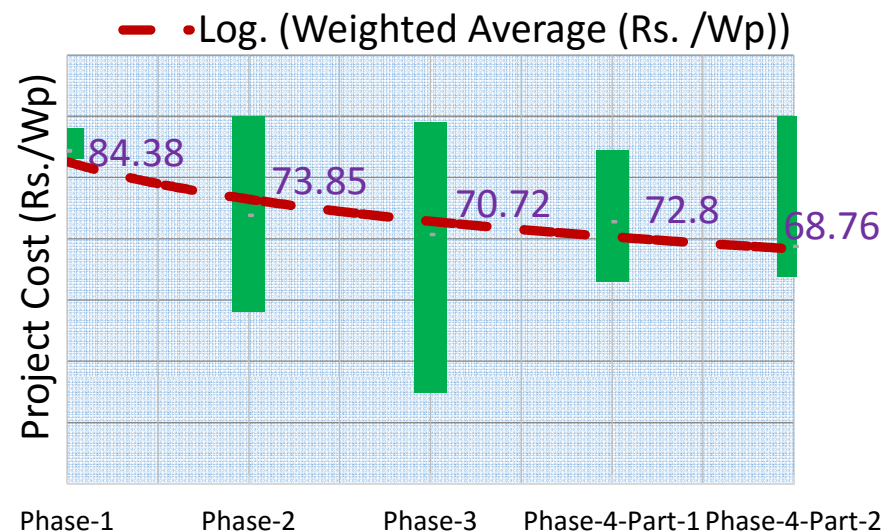


Source: CERC

Conversion:

1 ₹/Rs. = 1.32 € cent

**Project cost in SECI's Rooftop Schemes**

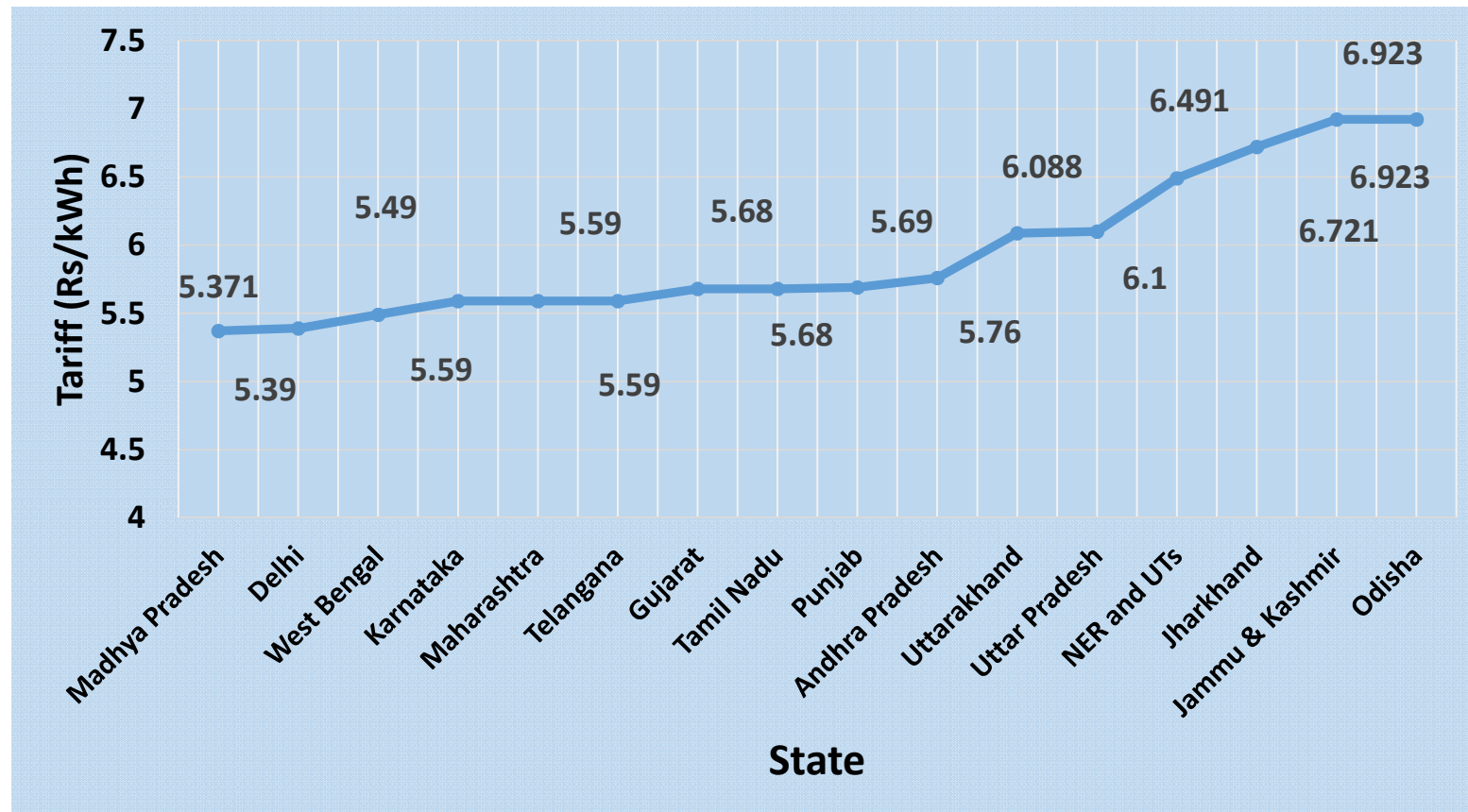


*Rooftop solar plants cost around 25% higher than ground based plants*

## Solar PV costs declining due to:

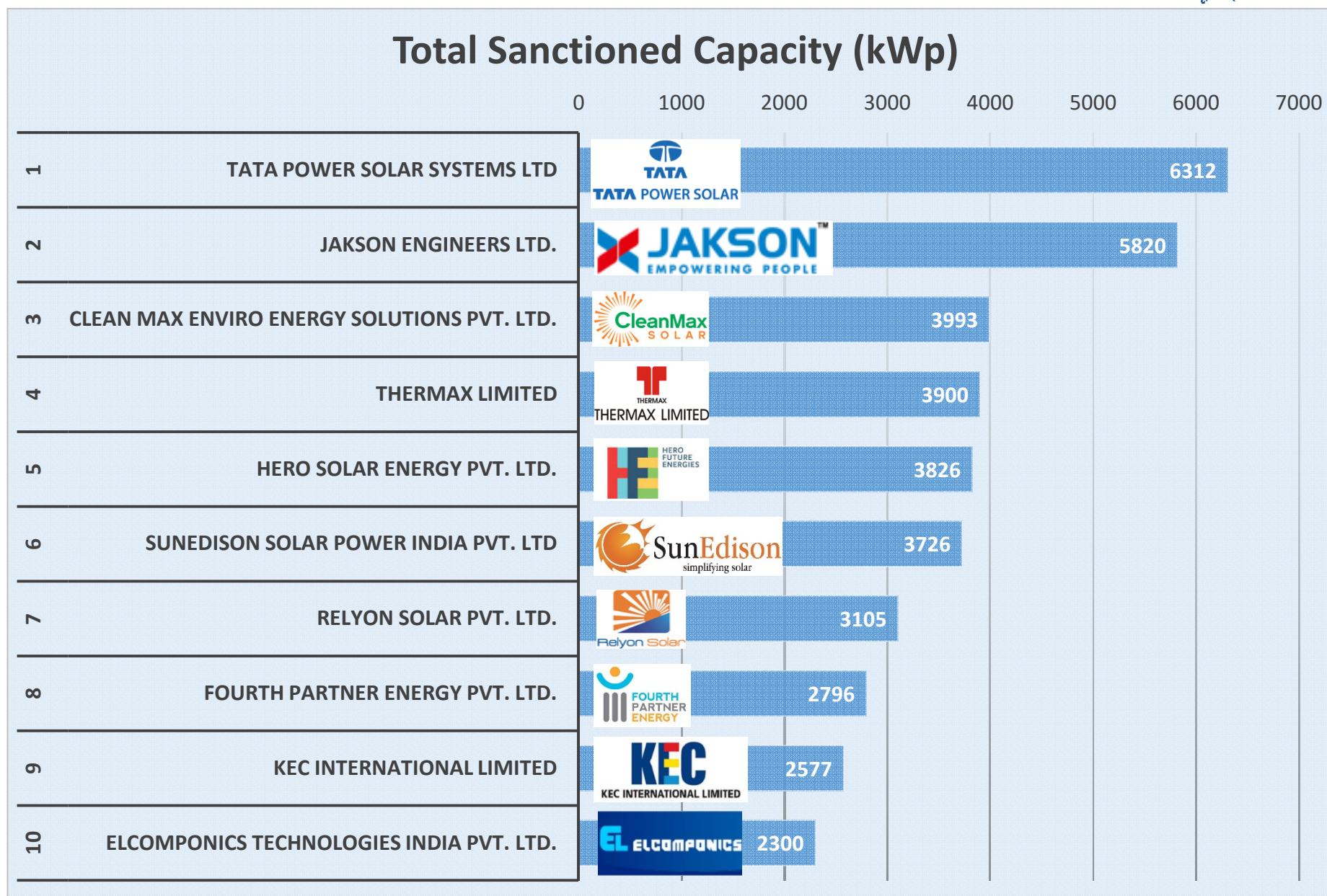
- Advancement of Technologies
- Learning Curve
- Economies of Scale
- Increased Competition

# Trend of Solar Rooftop PV Levellised Tariff



**Weighted average tariff : Rs. 5.74/kWh**  
**Maximum: Rs. 6.92/kWh**  
**Minimum : Rs 5.37/kWh**

# Top 10 vendors in SECI's Rooftop Program



# Prompting a Rooftop Solar Revolution with 500 MW Tender

## Salient Features (Subsidy Scheme)

- Target Group: Residential, Hospitals, Institutions, Social Sector
- 30% CFA is available for General Category States & UTs
- 70% CFA is available for Special category States viz: NE, Sikkim, Uttarakhand, HP, J&K, Lakshadweep, A&N Islands
- CFA is not available for Govt. Institutions, PSUs, Private Commercial and Industrial establishments
- Provision has been kept for capacity transfer from one state to another at lowest price of both states
- Technical evaluation of bids complete; Letters of Allocation issued
- MNRE has developed standard format of Power Purchase Agreement for RESCO bidders and Agreement for EPC bidders

## Contd..

- 300 MWp: Capex Mode in which Project cost based competitive bids invited
  - 200 MWp for Larger capacity (Part A) (26 kWp to 500 kWp)
  - 100 MWp exclusively for residential and smaller capacities (< 25 kWp) (Part C)
- 200 MWp: RESCO Mode in which Tariff based competitive bids invited (Part B)
- Scheme will be for “PAN India” basis
- State-wise bids will be invited
- Scheme simple & market friendly





# Highlights: 500 MW Rooftop tender



**Total Bidders: 132      Successful Bidders: 122, MSMEs: 81**

## ➤Part A:-

- **Lowest Project Cost: Rs. 53/Wp (Tamil Nadu, Maharashtra, Karnataka, Gujarat)**
- **Highest Project Cost: Rs. 72/Wp (Jharkhand)**

## ➤Part B:-

- **Lowest Tariff (70% subsidy): Rs. 3/kWh (Himanchal Pradesh, Uttarakhand)**
- **Highest Tariff(70% subsidy): Rs. 4.81/kWh (North East)**
- **Lowest Tariff (30% subsidy): Rs. 4.459/kWh (Maharashtra)**
- **Highest Tariff (30% subsidy): Rs 6.123/kWh (Gujarat)**

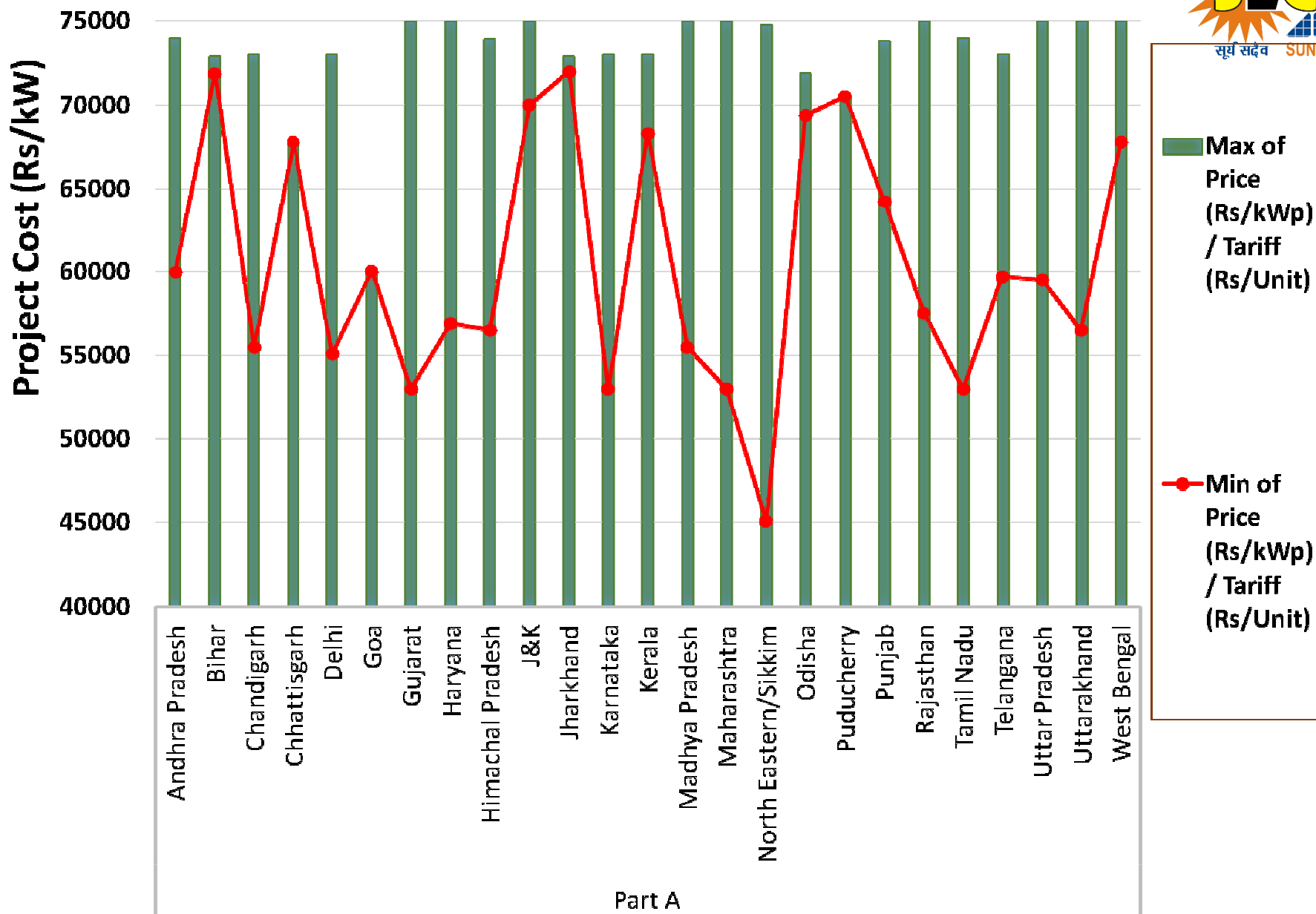
## ➤Part C:-

- **Lowest Project Cost: Rs. 57/Wp (Delhi)**
- **Highest Project Cost: Rs. 74.95/Wp (Andaman & Nicobar, Lakshadweep)**

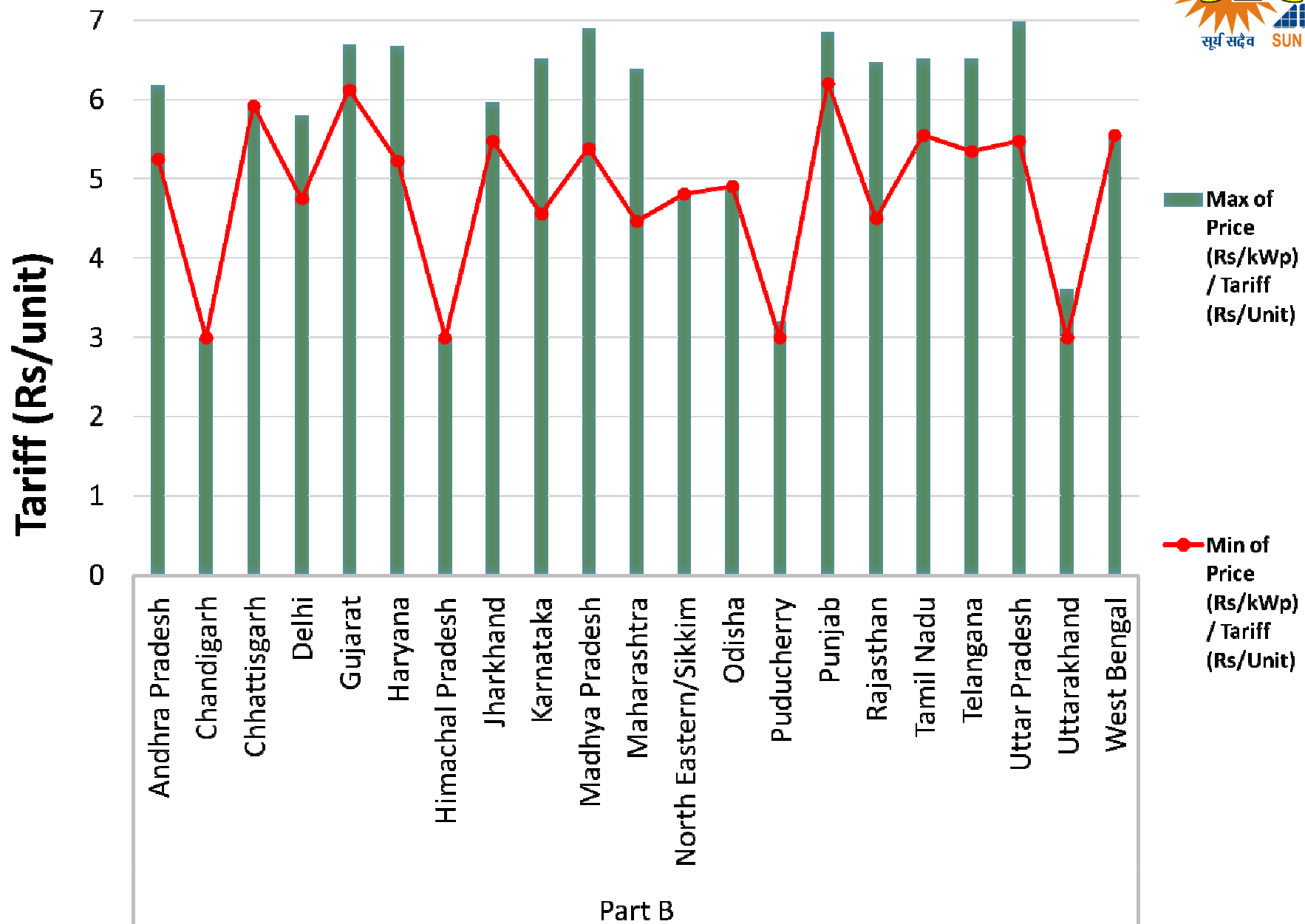
## Key Statistics: 500 MWp scheme

<b>Part</b>	<b>No of Successful Bidders</b>	<b>Allocated Capacity MWp as per RfS</b>	<b>Actual Allocated Capacity in MWp</b>
<b>A</b>	47	200	193.6
<b>B</b>	14	200	97.65
<b>C</b>	93	100	141.205
<b>TOTAL</b>		<b>500</b>	<b>432.455</b>

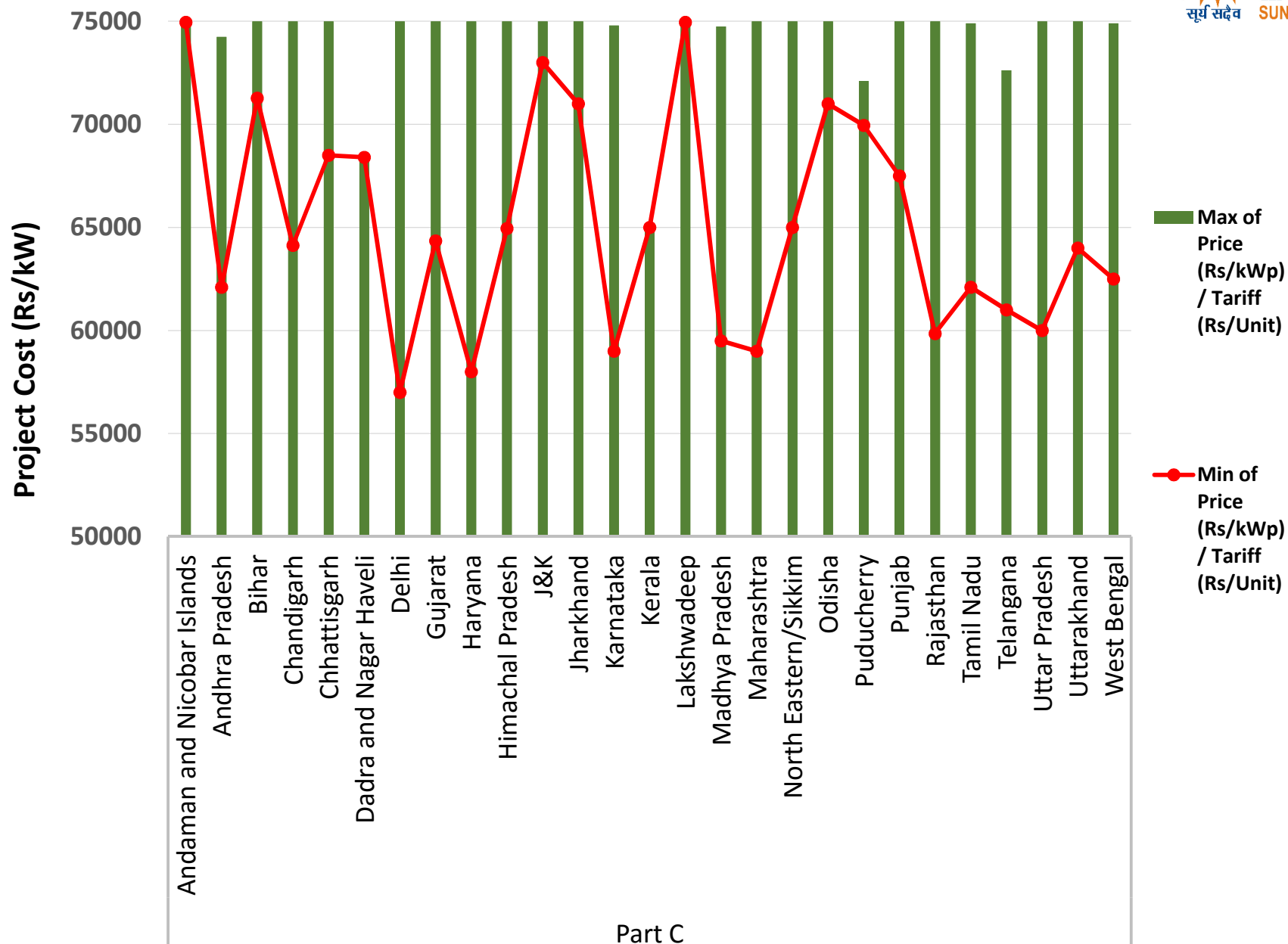
## STATE-WISE MIN-MAX PRICE TREND IN PART A CATEGORY



# STATE-WISE MIN-MAX TARIFF TREND IN PART B CATEGORY



## STATE-WISE MIN-MAX PRICE TREND IN PART C CATEGORY





## List of vendors in Part A



SI No	Name of Vendor	Participating States
1	Amogeo Ites India Limited	2
2	Artheon Electronics Pvt Ltd	5
3	Banco Construction Pvt Ltd	6
4	Benara Bearings & Pistons Limited	1
5	Bosch Limited	11
6	D.D. Project Services Pvt Ltd	1
7	Empire Photovoltaic System Private Limited	1
8	Fourth Partner Energy Pvt Ltd	16
9	Gensol Engineering Private Limited	4
10	Genus Innovation Ltd	5
11	Goldi Green Technologies	2
12	GPR Power Solutions Pvt Ltd	1
13	Harsha Abakus Solar Pvt Ltd	2
14	Hasan Marketing Pvt Ltd	4
15	Hero Solar Energy Pvt Ltd	13
16	HFM Solar Power Pvt Ltd	2
17	Jakson Engineers Ltd	4
18	JJ PV Solar Pvt Ltd	2
19	Kalthia Engineering And Construction Ltd	3
20	Madhav Infra Projects Ltd	2
21	Medors Renewable Energy Pvt. Ltd.	3
22	Modern Solar Private Limited	1
23	MX Solar Power Limited	1

SI No	Name of Vendor	Participating States
24	Pes Engineers Pvt Ltd	2
26	Purshotam Profiles Pvt. Ltd.	6
27	Ravindra Energy Limited	4
28	Rays Power Experts Pvt Ltd	3
29	Relyon Solar Pvt. Ltd	4
30	Renew Solar Energy Pvt Ltd	7
31	Rk Tech (India) Pvt Ltd	2
32	Sharika Enterprises Pvt Ltd	1
33	Solartown Energy Solutions Pvt Ltd	3
34	Solarworld Energy Solutions Private Limited	2
35	Span Pumps Pvt Ltd	1
36	SPML Infra Ltd	5
37	SR Corporate Consultant Pvt Ltd	6
38	Sri Avantika Contractors (I) Limited	4
39	Sterling & Wilson Pvt Ltd	8
40	Sudhir Power Projects Ltd	3
41	Sukhbir Agro Energy Limited	5
42	Suncraft Energy Private Limited	1
43	Sure Energy Systems Private Limited	6
44	Ultimate Sun Systems Pvt. Ltd.	1
45	Uneecops Technologies Ltd	1
46	U-Solar Clean Energy Solutions Pvt. Ltd.	2
47	Zodiac Energy Pvt. Ltd.	1

## List of vendors in Part B



SI No	Name of Vendor	Participating States
1	Amplus Energy Solution PrivAte Limited	10
2	Cambridge Energy Resources Pvt. Ltd.	6
3	Clean Max Enviro Energy Solutions Pvt Ltd	9
4	Dexler Holdings Pvt Ltd	2
5	Fourth Partner Energy Pvt Ltd	9
6	HFM Solar Power Pvt Ltd	2
7	Jakson Engineers Ltd	8
8	Madhav Infra Projects Ltd	1
9	Ravindra Energy Limited	2
10	Renew Solar Energy Pvt Ltd	9
11	Solarworld Energy Solutions Private Limited	2
12	Span Pumps Pvt Ltd	1
13	SR Corporate Consultant Pvt Ltd	2
14	Vyomaa Energy Private Limited	1

## List of vendors in Part C



Sl No	Name of Vendor	Participating States
1	8minutes Future Energy Pvt. Ltd.	1
2	21" Century Enviro Engineers Pvt Ltd	8
3	Aadi Technologies Pvt Ltd	1
4	Abhishek Enterprises	2
5	Ablers Services Private Limited	6
6	Ados Renewable Private Limited	2
7	Advit Ventures Private Limited	3
8	Alien Energy Private Limited	10
9	Amogeo Ites India Limited	3
10	Aryav Green Energy Private Limited	4
11	Aston Greens Private Limited	1
12	Augni Renewable Energy System India Private Limited	2
13	Banco Construction Pvt Ltd	4
14	Bhamri Enterprises	4
15	Bluearth Energy Pvt Ltd	4
16	Boond Engineering And Development	8
17	Calypte Advisors LLP	4
18	Central Electronics Ltd	1
19	CVK Solar Enterprises Private Limited	4
20	D.D. Project Services Pvt Ltd	1
21	Dadhwai Solar Private Limited	3
22	Deshmukh Electrical Consultant Private Limited	1

Sl No	Name of Vendor	Participating States
23	El-Sol Energy Systems	3
24	Enfrosun Power Private Limited	3
25	Firstgreen Consulting Pvt Ltd	4
26	Freyr Energy Services Private Limited	5
27	Gears Energy Solution Private Limited	4
28	Gensol Consultants Private Limited	2
29	Geopower India Private Limited	3
30	Goggles Energy Private Limited	1
31	Goldi Green Technologies	2
32	GP Eco Solutions India Pvt Ltd	4
33	GPR Power Solutions Pvt Ltd	3
34	Green First Power Ventures Pvt Ltd	2
35	Greentek India Pvt Ltd	7
36	Hero Solar Energy Pvt Ltd	3
37	HFM Solar Power Pvt Ltd	2
38	Highground Energy Pvt Ltd	3
39	HIQ Power Associates Pvt Ltd	5
40	Iacharya Silicon Ltd	2
41	Innovative Roof Solar Solutions Llp	3
42	Integrated Engineers & Consultants Pvt Ltd	3
43	International Marketing Corporation	2
44	Jai Mata Di Solar Energy Pvt Ltd	1

## List of vendors in Part C



Sl No	Name of Vendor	Participating States
45	Jaiswal Battery Services	4
46	JJ PV Solar Pvt Ltd	1
47	Karmasukom Energy	6
48	KBS Certification Service Private Limited	11
49	Kwatt Solutions Pvt Ltd	1
50	Libra Solutions	5
51	Medors Renewable Energy Pvt. Ltd.	3
52	Modern Solar Private Limited	2
53	Networth Projects Private Limited	2
54	Oakbridge Energy Private Limited	4
55	Photon Energy Systems Ltd	4
56	Pinak Power Associates (Opc) Pvt. Ltd.	5
57	Pious Solar Energy Pvt Ltd	4
58	Plexus Infratech Private Limited	7
59	Power One Micro Systems Pvt Ltd	4
60	Powertech Engineers	1
61	Punam Energy Pvt Ltd	7
62	Purshotam Profiles Pvt. Ltd.	2
63	Raydeon Energy Private Limited	1
64	Rays Power Experts Pvt Ltd	4
65	Renew Solar Energy Pvt Ltd	6
66	Rk Tech (India) Pvt Ltd	2
67	Rmb Power Projects Private Limited	4
68	Saranya Electronics Pvt Ltd	5

Sl No	Name of Vendor	Participating States
69	SDSL Electronics Private Limited	4
70	Shakti Trans Infra	1
71	Sharika Enterprises Pvt Ltd	1
72	Skylark Industries	3
73	SLG Solar Systems	5
74	Smart Roof Solar Solutions Pvt Ltd	3
75	Solarplus Energy Pvt Ltd	1
76	Solartown Energy Solutions Pvt Ltd	5
77	Span Pumps Pvt Ltd	1
78	SRK Solenergi Private Limited	1
79	Star Energy Systems	1
80	Statcon Energiaa Pvt Ltd	2
81	Su Solartech Systems (P) Ltd	4
82	Sudhir Power Projects Ltd	2
83	Sukhbir Agro Energy Limited	4
84	Suncraft Energy Private Limited	1
85	Sunrator Technologies Llp	5
86	Sunshell Power	1
87	SunSwitch India Pvt Ltd.	6
88	Uratom Solar (India) Private Limited	8
89	U-Solar Clean Energy Solutions Pvt. Ltd.	1
90	Xpanz Energy Solutions Llp	3
91	Zeus Solar Epc Pvt. Ltd.	2
92	Zivah International Private Limited	4
93	Zodiac Energy Pvt. Ltd.	4

### List of empanelled experts

Sl. No.	Name	Contact No	Email Id
1	Shatrughan Singh Shekhawat	9461161897	<a href="mailto:shekhawatmrec1973@gmail.com">shekhawatmrec1973@gmail.com</a>
2	PC Sharma	9957569797	<a href="mailto:pcsarma@mail.com">pcsarma@mail.com</a>
3	N Ramamurthy	9900261312	<a href="mailto:ramamurthy55@yahoo.com">ramamurthy55@yahoo.com</a>
4	Arvind Kumar	9453042371	<a href="mailto:yr_arvind@hotmail.co">yr_arvind@hotmail.co</a>
5	Mahesh Kumar Jain	9414036414	<a href="mailto:mkjain49@gmail.com">mkjain49@gmail.com</a>
6	P K Mohanty	9437138887	<a href="mailto:pkm1@rediffmail.com">pkm1@rediffmail.com</a>
7	S L Davera	9414889659	<a href="mailto:sldavera50@gmail.com">sldavera50@gmail.com</a>
8	P.K. Kaushal	9717697099	<a href="mailto:pkksk@yahoo.co.in">pkksk@yahoo.co.in</a>
9	A. Obul Reddy	9440228921	<a href="mailto:obulr1@gmail.com">obulr1@gmail.com</a>
10	N.K. Gulkotwar	9619578973	<a href="mailto:nkgulkotwar@Yahoo.com">nkgulkotwar@Yahoo.com</a>
11	Dr. Ahmar Raza	9711508944	<a href="mailto:ahmar_r@yahoo.com">ahmar_r@yahoo.com</a>
12	Rabinder Kant Sikri	9899097225	<a href="mailto:rksikri@gmail.com">rksikri@gmail.com</a>
13	Mahendra Pal Sharma	9415784319	<a href="mailto:mpsharma.neda@gmail.com">mpsharma.neda@gmail.com</a>
14	G Ravi Kumar	8028436021	<a href="mailto:ravikumar.gurumurti@gmail.com">ravikumar.gurumurti@gmail.com</a>



# Achievement - Linked Incentives Scheme

## Salient Features of the Scheme

- All Government implementing Ministries/Department/Organizations/Agencies /Institutions are eligible to participate in the scheme
- MNRE will earmarked the year wise target from 2015-16 to 2019-20 with CFA / Achievement Linked Incentives in consultation with
  - All State Governments,
  - All GoI Ministries/Departments and
  - Other GoI independent bodies like courts, Institutions, PSUs, etc., based on:
- Setting up of the targets will be based on
  - Willingness and consent of Government bodies to participate in the scheme
- The Targets shall be carry forwarded to the next year, if not completed, and added in the next year's target in consultation with entities

Contd..



## Salient Features of the Scheme

- The sanctioned/approved capacity/allocated targets will be applicable to all Government Institutions including Ministries/Departments/Organizations of both Central and State Government and PSUs.
- The achievement – linked incentives vis-à-vis allocated targets would be valid during the period of the implementation of ‘Grid Connected Rooftop & Small Solar Power Plants Programme’
- The Scheme may be implemented through Solar Energy Corporation of India Limited and respective Central / State Government Departments/ SNAs

Sl. No.	Achievement/Completion vis-à-vis sanction/ approval/target allocation within a sanctioned period	Incentive for General Category states	Incentive for Special Category states
1.	80% and above	Rs. 18,750/- per kWp	Rs. 45000/- per kWp
2.	Below 80% and upto 50%	Rs. 11,250/- per kWp	Rs. 27000/- per kWp
3.	Below 50% / delayed commissioning up to 6 months beyond the sanctioned period.	Rs. 7,500/- per kWp	Rs. 18000/- per kWp

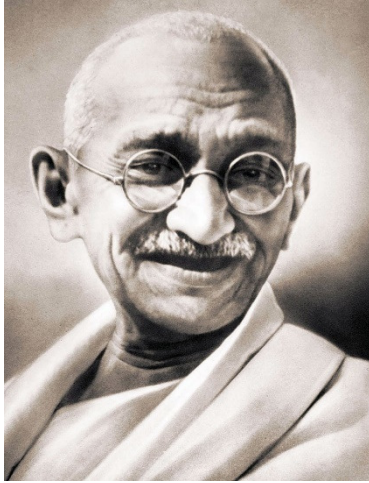
# Next in line: 1000 MW for Government/ Public Sector Undertaking Buildings



## Salient Features

- Achievement linked incentives/award scheme
  - Up to 25% incentive on project cost for 80% to 100% target achievement
- Targeted to all Ministries/Government buildings
- Buildings of Public Sector Undertakings (Both Central and State) are also covered
- MNRE/SNA to set target capacity – Annual Targets will be finalized
- The Scheme may be implemented through Solar Energy Corporation of India Limited, CPSUs, DISCOMs, ULBs, State Government departments/SNAs
- Implementation through open competitive process
- 700 MW for RESCO and 300 MW for CAPEX





“Be the change you want to see in the world”

**Thank you**  
Contact us  
[www.seci.gov.in](http://www.seci.gov.in)

# Standards & Compliance



## Components of Solar roof top power plant

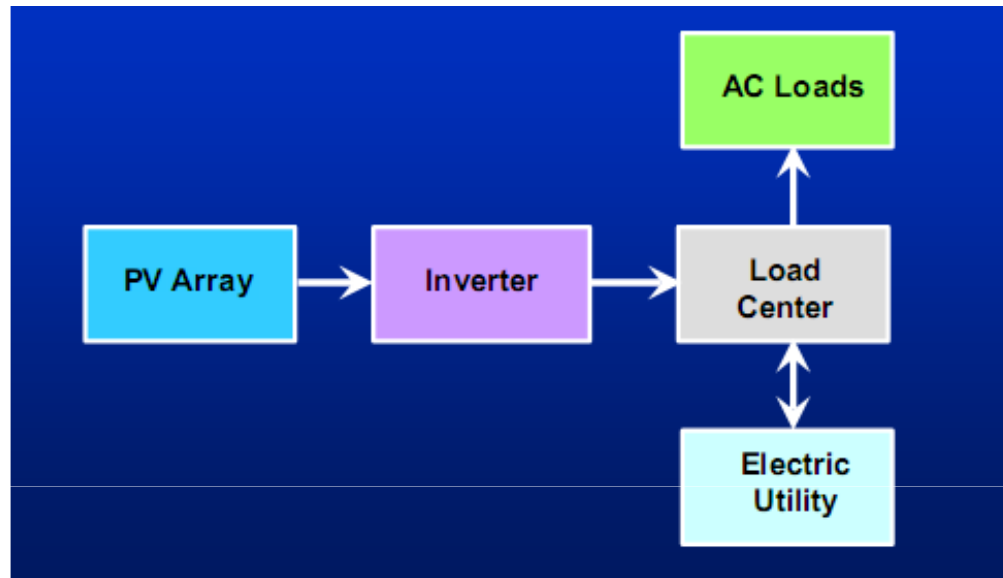
1. PV modules and array
2. Mounting structure and roof
3. Combiner box
4. DC disconnect
5. Inverter (charger and controller)
6. AC disconnect
7. Utility service panel
8. Battery (optional)



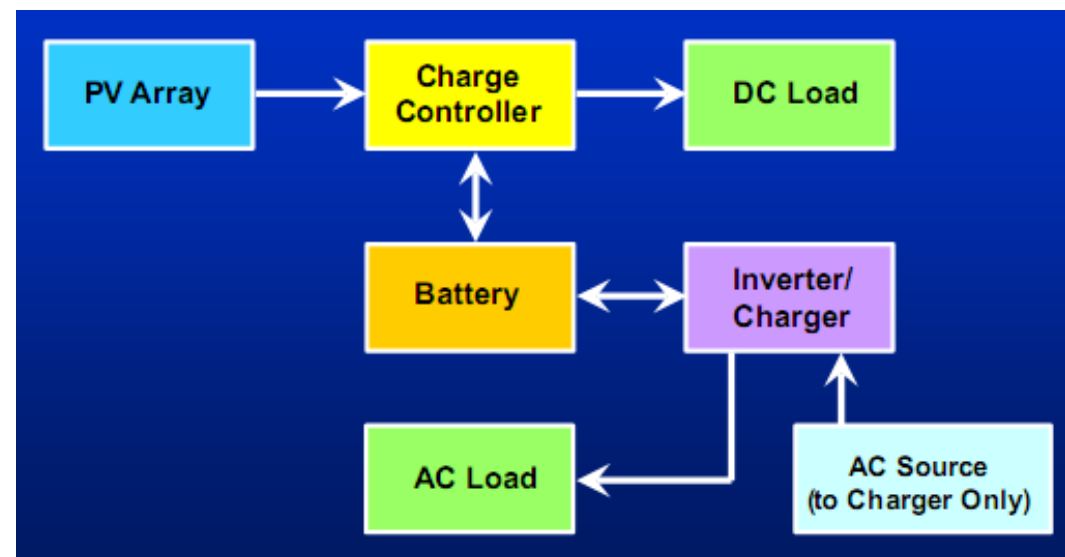


# Types of PV system

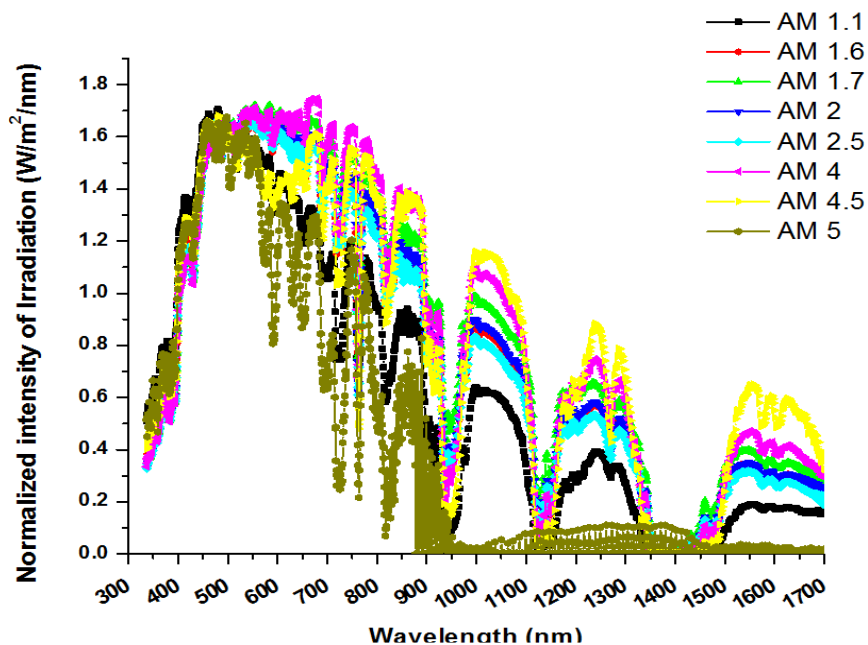
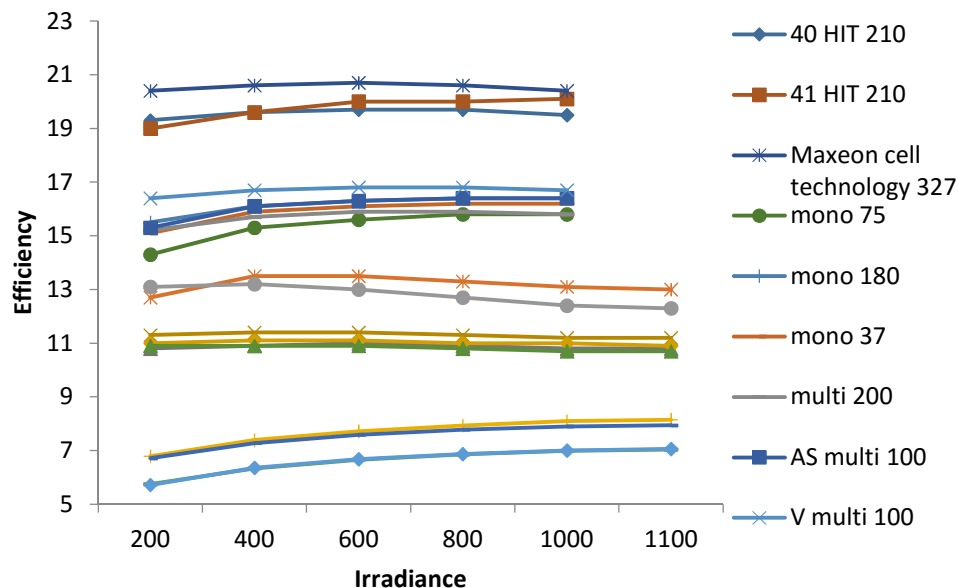
## Utility interactive PV system



## Stand alone system



# Module performance depends on irradiance, temp. and spectrum



Technology	Efficiency	degradation reported (Initial yr)
Mono-C- Si	15-20%	0.5-2.0%
Poly Si	13-15%	0.5-2.0%
CdTe	9-11%	1-2%
CIGS	9-11%	1-2%
A-Si	5-8%	1.5-2.5%
Sunpower	22%	0.32%

Technology	Power temperature coefficient ~
MONO -CRYSTALLINE	-0.485%/Deg
MULTI -CRYSTALLINE SILICON	-0.46%/Deg
A-Si ( SINGLE, DOUBLE & TRIPLE JUNCTION)	-0.25%/Deg , -0.3%/Deg & -0.3%/Deg
CIS	-0.31%/Deg
CdTe / CdS	-0.25%/Deg
Sun Power (Maxeon©)	0.35 %/C
CIGS	-0.36 %/°C
Micromorph	-0.3%/Deg

# Standards for module testing



<b>IEC 61215/ IS 14286</b>	Design Qualification and Type Approval for Crystalline Silicon Terrestrial Photovoltaic (PV) Modules
<b>IEC 61646/ IS 16077</b>	Design Qualification and Type Approval for Thin-Film Terrestrial Photovoltaic (PV) Modules
<b>IEC 61701- As applicable</b>	Salt Mist Corrosion Testing of Photovoltaic (PV) Modules
<b>IEC 61853- Part 1/ IS 16170 : Part 1</b>	Photovoltaic (PV) module performance testing and energy rating –: Irradiance and temperature performance measurements, and power rating
<b>IEC 62716</b>	Photovoltaic (PV) Modules – Ammonia (NH <sub>3</sub> ) Corrosion Testing
<b>IEC 61730-1,2</b>	Photovoltaic (PV) Module Safety Qualification – Part 1: Requirements for Construction, Part 2: Requirements for Testing
<b>IEC 62804 (Draft Specifications)</b>	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation. IEC TS 62804-1: Part 1: Crystalline silicon
<b>IEC 62759-1</b>	Photovoltaic (PV) modules – Transportation testing, Part 1: Transportation and shipping of module package units

# Radio-frequency identification



India's National Solar Mission mandates that each PV module used in solar power project must use a Radio-frequency identification (RFID) tag containing (storing) information regarding:

- Manufacturer,
- Origin & technical data as per MNRE standards

As per MNRE, each PV module must have an RFID tag containing following information:

- Name of the manufacturer of PV Module
- Name of the Manufacturer of Solar cells
- Month and year of the manufacture (separately for solar cells and module)
- Country of origin (separately for solar cells and module)
- I-V curve for the module
- Peak Wattage,  $I_m$ ,  $V_m$  and FF for the module
- Unique Serial No and Model No of the module
- Date and year of obtaining IEC PV module qualification certificate
- Name of the test lab issuing IEC certificate
- Other relevant information on traceability of solar cells and module as per ISO 9000 series

# SELECTION OF INVERTERS/ PCU

# Type of inverters

- Stand-alone up to 100KVA
- Hybrid Inverters (SMD Type) up to 200KVA

- String Inverters 1 to 50 KVA

- Large capacity Centralized GI Inverters

- Major Features Of Inverters:

- ✓ Modes of Operation
- ✓ System Voltage and polarity
- ✓ Power Factor and Reactive power
- ✓ Efficiency Vs Load performance
- ✓ MPPT range
- ✓ Islanding Protection Voltage & frequency
- ✓ Low Voltage ride through
- ✓ Protections
- ✓ Environment and IP certifications





## Stand alone inverter

- Stand-alone PV systems are designed to operate independent of the electric utility grid, and are generally designed and sized to supply certain DC and/or AC electrical loads.
  - With an inverter to power AC loads
  - Best suited for Remote Electrification requirement, with 1-2 days of Autonomy.
  - For systems with no battery the energy is used immediately like in water pump application. only works when it's sunny
  - Common applications are direct power to DC loads, water pumping and telecommunications



# Grid Tied inverter



- **MICRO INVERTER**

- Panel level Inverter with MPPT, located on the back of or situated very close to a solar panel .
- Rating typically below 500W



- **STRING INVERTER**

- String Level Inverter
- Rating Typically 5KW-100KW
- Used in roof top applications in KW scale installation.

- **CENTRAL INVERTER**

- Big Size Inverter with large arrays installation.
- Rating Typically 250KW-800KW (commonly used)
- Used for big Solar Parks in MW scale installation.



# Technology behind GT inverter

## Transformer based grid tied inverter

1. It prevents dc components to utility side or provide isolation between input and output.
2. If string voltage is high, generally it is suggested that the negative DC terminal has to be grounded to avoid PID.
3. If DC input has a conduction path to output, the output AC conductors in utility-interactive configurations should be isolated from DC input.



# Grid tied Inverters without Isolation

1. The transformer less inverters of are high efficiency and lower weight and cost.
2. Because of the lack of the galvanic isolation, these models present potential electrical hazards.
3. There are chances of DC power component to be fed into utility side. If a person touches the terminal of PV panel, may experience AC line voltage.
4. They are used especially in that country/location where ungrounded electrical systems are common.

## Selection Criterion for grid tied Inverter

1. Efficiency of GTI inverter.
2. Efficiency of MPPT & effect of temperature.
3. Range of MPPT w.r.t. different technology of PV module (discussion about temperature effect on Voc of PV module.)
4. Capacity of inverter w.r.t. power plant (discussion w.r.t. Different technology of PV module, operation due to different weather conditions)

## Standards for Inverters

- IEC 61683 – Procedure for measuring efficiency
- IEC 62116- Islanding protection
- IEC 61727- Parallel operation of inverter
- EN 50530- Measuring the efficiency of MPPT algorithm
- IEC 60068-2(1,2,14,30) –Environmental tests

# Installation Guideline for mounting of the PV array



- Roof assessment:
  - Type of roof
  - Roof structure (typical 20-25 kg/sblyqm)
  - Structure analysis – to asses load bearing capacity of the roof
- The mounting rack could be fixed or discontinuous/continuous adjustable.
  - Flat roof: South facing modules preferably
  - Sloped roof based on the orientation
- Under certain circumstances such as avoiding shading effect, the direction could be adjusted to  $\pm 15$  degrees from south to optimize annual generation.
- In case of high wind area lower tilt angle in the range of 5-20 degrees should be used to reduce the wind loading.
- The installation site of the modules should be chosen to avoid shadings
- Adequate spacing should be added between arrays to avoid the shading from each other

The supporting structure should be designed

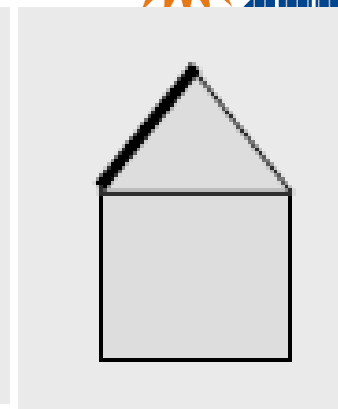
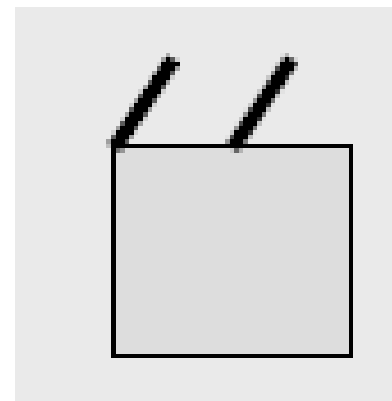
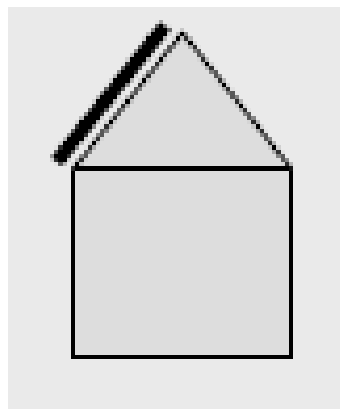
- Based upon the comprehensive consideration of geological environment,
- wind load,
- site conditions and
- the specifications of the modules to ensure the strength, safety and reliability of the PV array

When designing rooftop type installation the supporting interface's

- load bearing capacity should be considered, and
- the design of the project should meet the demand of related building standards.

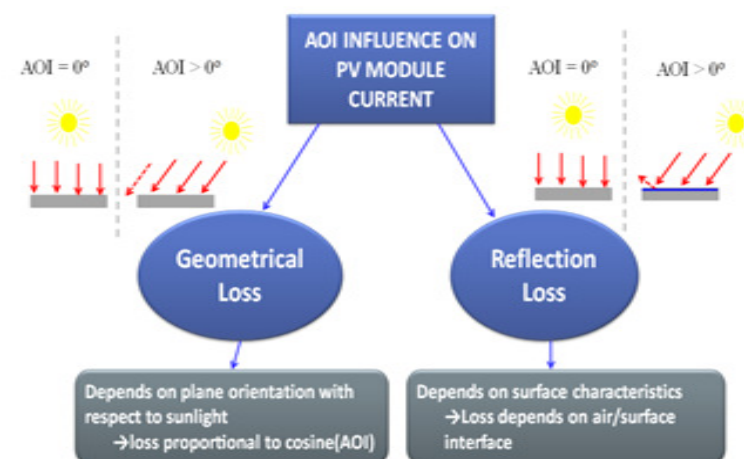
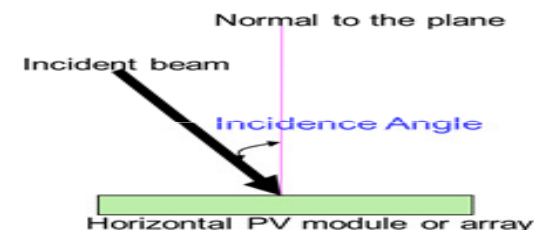
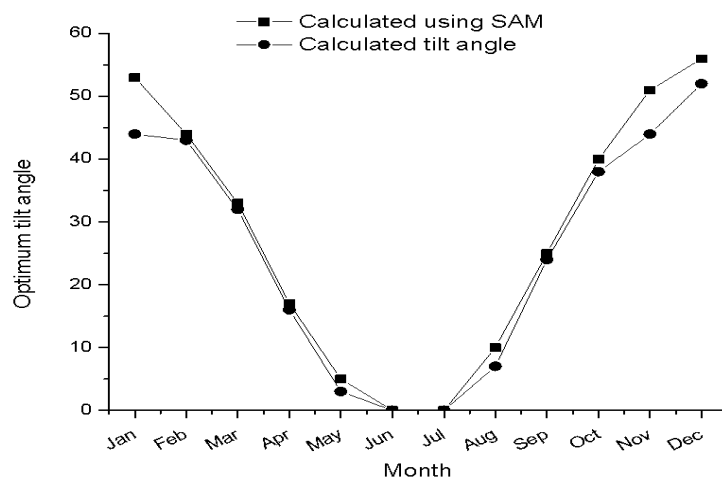
# Installation of module

- Rooftop
- Flat roof
- Roof-integrated



## Losses due to fixed tilt

- Radiation losses
- Reflection losses
- Cosine losses



## Standards Used

- IEC 62548: Ed 1 Installation and Safety Requirements for Photovoltaic (PV) Generators;
- IEC 61194: 1992 Ed 1, Characteristic parameters of stand-alone photovoltaic (PV) systems
- IEC 62446: 2009 Ed 1 Grid connected photovoltaic systems - Minimum requirements for system documentation, commissioning tests and inspection



# Monitoring, operation and maintenance

# Performance indices of PV Power plant

$$\text{Energy Yield } (Y_f) = (\text{kWh/kWp}) \text{ or } (\text{Hours})$$

$$= E \text{ (Energy output)} / P_o \text{ (STC DC Power)}$$

$$\text{Reference Yield } (Y_r) = \text{kWh/kW (1000 W)}$$

$$= H \text{ (In Plane Irradiance)} / G \text{ (1000 W/M}^2\text{)}$$

$$\text{PERFORMANCE RATIO (PR)} = Y_f / Y_r$$

$$\text{Performance index} = \text{Measured energy} / \text{Predicted Energy}$$

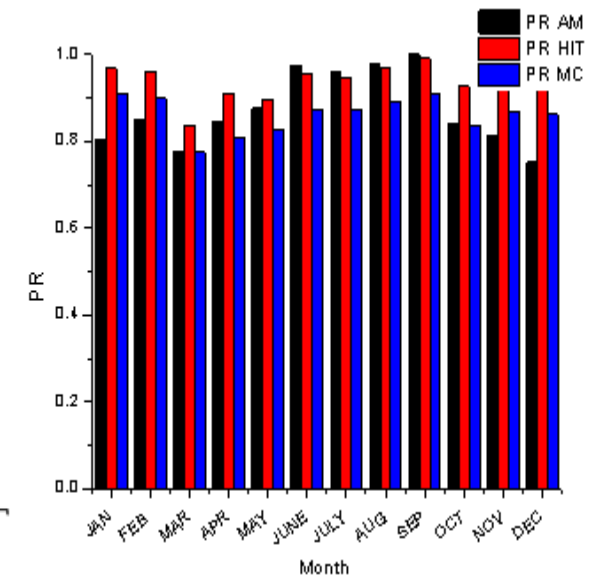
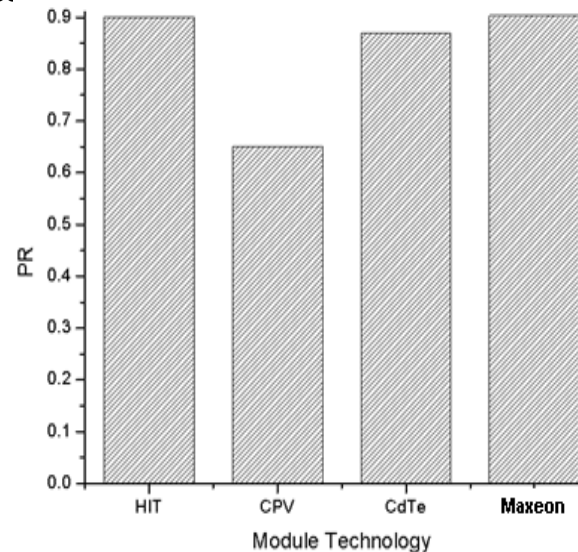
$$\text{Capacity Utilization Factor (CUF)} = \text{Energy measured (kWh)} / (365 * 24 * \text{installed capacity of the plant}).$$

PR is dimension less, Quantifies Effect of Losses

PR depends on site Temperature, Spectrum, Technology and Degradation

**Calculation methods of STC conversion for outdoor measured I-V data**

**I. IEC 60891**





# Maintenance

**Most important safety necessities during solar PV power plant operation are**

- Lockout procedure
- The use of personal protective equipment (PPE)
- securely disconnecting live cables /paths
- Appropriate examination and in conformity with the entire solar power installations specific system signage and warnings.



**Steps for diagnosing power production deficiencies include**

- Checking of fuse
- System performance data review
- Check the onsite performance meters
- Verify that the array maximum power point voltage is in the maximum power point tracking window of the inverter. Modules used to degrade over time.
- Checking for unexpected shading
- Look for soiling.
- Validate weather station



## Standards

- IEC 61724: 1998 Ed 1, Photovoltaic system performance monitoring –guidelines for measurement, data exchange and analysis
- IEC 61725: 1997 Ed 1, Analytical expression for daily solar profiles
- IEC 61727: 2004 Ed 2, Photovoltaic (PV) systems – Characteristics of the utility interface
- IEC 62446: 2009 Ed 1 Grid connected photovoltaic systems -Minimum requirements for system documentation, commissioning tests and inspection



# Net Metering

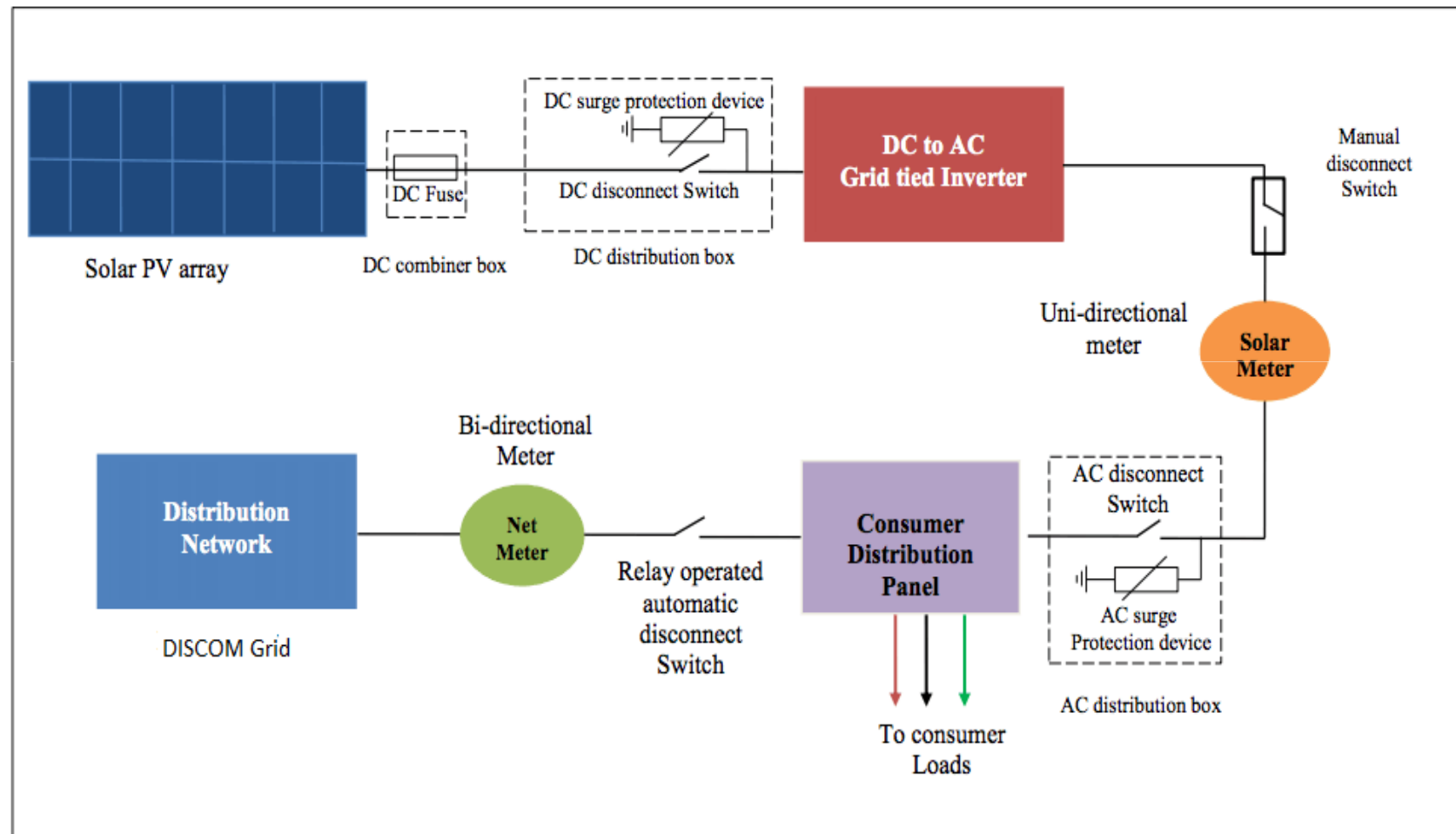
# What is Net Metering?

- The net metering based rooftop solar projects facilitates the self-consumption of electricity generating by the rooftop project and allows for feeding the surplus into the network of the distribution licensee
- The rooftop solar projects may have two distinct ownership arrangements. —
  - Self-owned arrangement wherein rooftop owner also owns the PV system
  - Third party ownership in which a developer owns the PV system and also enters into a lease/commercial arrangement with the rooftop owner.

## Contd...

- Net-metering facility shall be extended to the solar power system installed in establishments /consumers connected to the electrical grid
- These consumers are the “eligible consumers” for the purpose of net-metering
- Interconnection framework (the interface of Renewable Energy source with the network of distribution licensee) for net-metering shall address parameters including
  - Connecting voltage level, any minimum technical standards for interconnection as indicated by the concerned state Commission regulation and
  - As per technical standards for Connectivity of Distributed Generation resources Regulations 2013 notified by Central Electricity Authority

**Single Line Diagram of Rooftop Facility for Net Metering Interconnection**



# What is Gross Metering?

- Gross metering arrangement, the entire energy generated by rooftop solar PV system is fed directly into the electrical grid and the system owner is benefited by feed-in-tariff based on sale of power to the utility
- International Experience
  - Germany is the most well-known example of a successful propagation of the gross metering concept, in which the rooftop solar projects sell electricity directly to the local grid at a declared FiT
  - Japan and several states in the United States, on the other hand, have implemented net-metering concept where the energy is self-consumed before the surplus is sold to the grid. The recent trend in Japan has been to progressively move towards a gross metering model with FiT mechanism

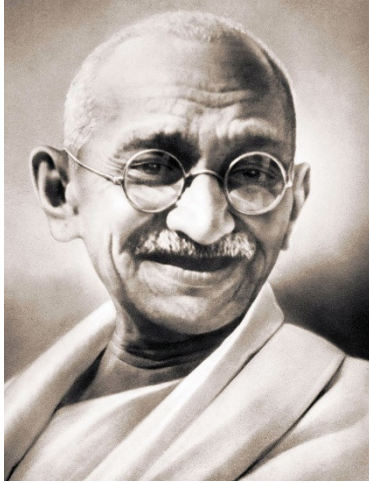


# Gross v/s Net Metering

Parameter	Gross Metering	Net Metering
Objective	Electricity sale to utility	Self-consumption of electricity
Contractual Arrangement	Power Purchase Agreement (PPA) with the utility Price determined by Regulator or based on Competitive Bidding	Arrangement between utility and consumer in case the excess electricity sale is allowed
Metering Requirement	Compliance with the specifications of generation meter	Metering arrangement to measure generation as well as respective consumption
Energy Accounting	Accounting for the solar generation	Accounting for the net power consumption by the consumer as well as solar generation (in case it is linked to any benefits/ incentives)
Beneficiary	Enables the utility to meet its Solar RPO compliance	Enables the consumer in reducing the electricity consumption from the grid
Utility's Concern	Not keen on signing PPA with small rooftop projects	Loss of revenue for utility
Developer's Concern	Grid unavailability to impact revenue	Low level of incentive may impact viability of project for certain consumer segments

Source: Deloitte

# Solar Tariff



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