Confederation of Indian Industry

Renewable Energy Opportunities

4th ChemPharma Summit 2024, HICC, Hyderabad

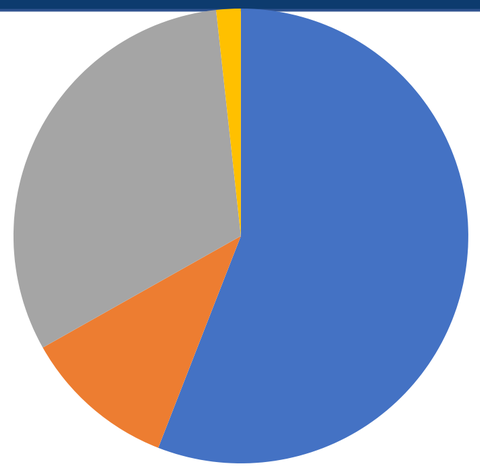
21st June 2024

Agenda of the Presentation

- Power Scenario in India
- Levers for Net Zero
- Renewable Energy Options
- Current Trends in Solar Cell/ Module and Wind Technologies
- Case Studies: RE Technologies
- Performance Improvement of Rooftop & Ground Mounted Solar Plants
- Best Practices & Case Studies for Ground Mounted Solar Plants
- What can Chemical and Pharmaceutical Industry do?

Power Scenario in India

Power Scenario in India



- **Installed Power Generation Capacity*: 429.9 GW**
  - Fossil Fuel (Coal, Lignite, Gas & Diesel): 240.4 GW
  - Large Hydro: 46.9 GW
  - Renewable Sources (Wind, Solar, Biomass, Waste to Energy & Small Hydro): 135.1 GW
  - Nuclear: 7.5 GW

- **Govt. of India's RE vision**
  - In COP-26, Honorable PM committed that India would install 500 GW RE & meet 50% of energy requirement from RE by 2030
  - India also aspires to become 'Net Zero' by 2070

*Status as on 31st Jan 2024

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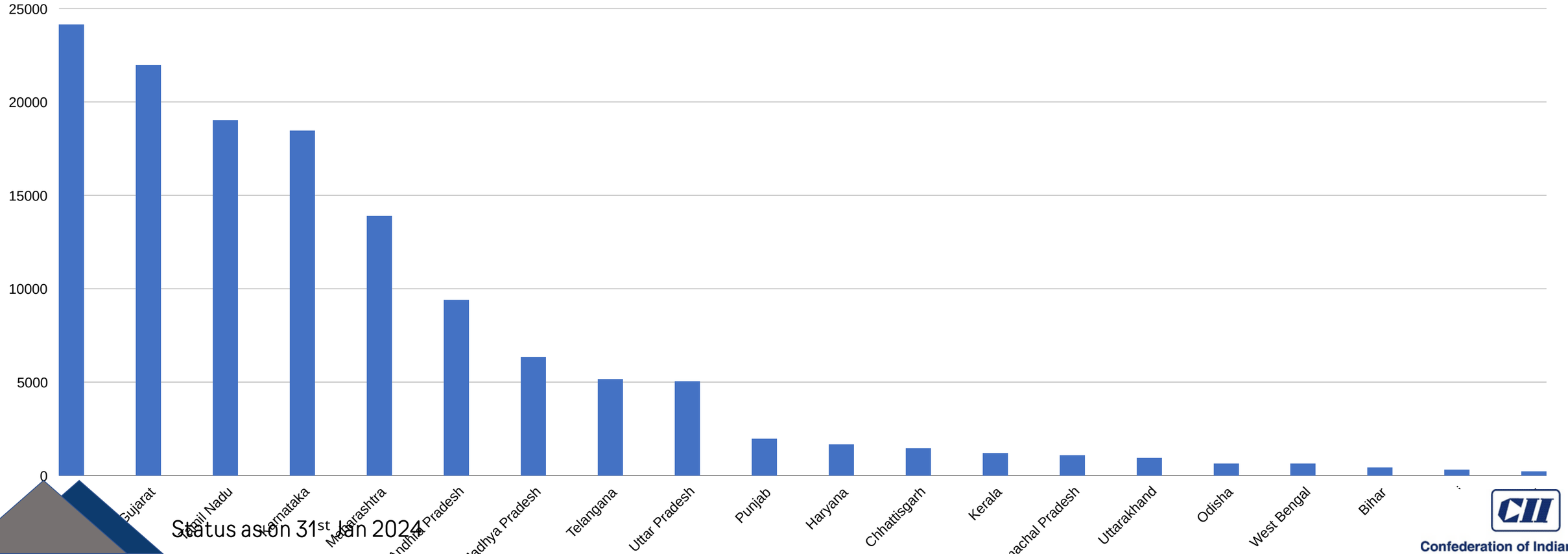
Leading RE States in India

S. No.	State	Capacity (MW)
1	Rajasthan	24,139
2	Gujarat	21,977
3	Tamil Nadu	19,035
4	Karnataka	18,469
5	Maharashtra	13,888

S. No.	State	Capacity (MW)
6	Andhra Pradesh	9,392
7	Madhya Pradesh	6,348
8	Telangana	5,152
9	Uttar Pradesh	5,054
10	Punjab	1,975



Status as on 31st Jan 2024

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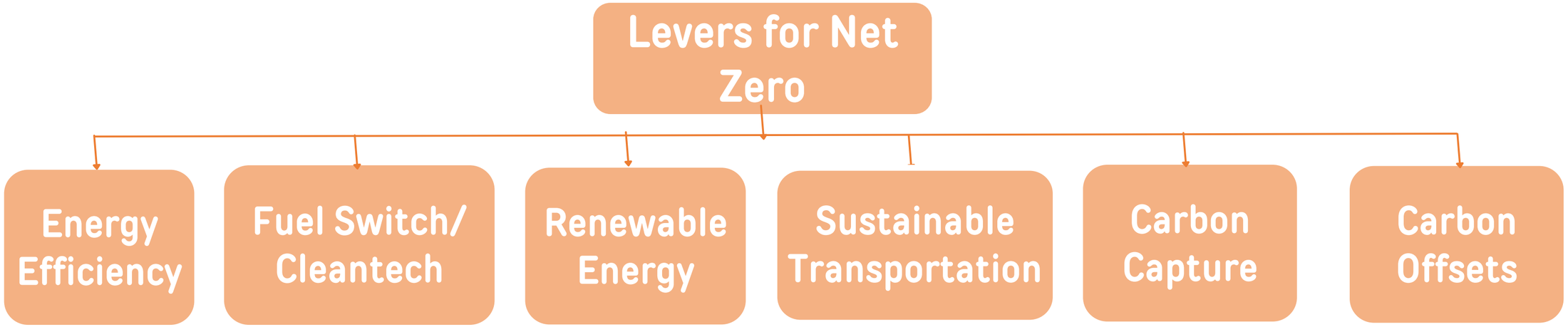
Levers for Net Zero

Levers for Net Zero



- After Energy Efficiency, RE is the most cost-effective lever for achieving net zero
- Multiple technology options are available
- Favourable policy ecosystem in many States
- Option is fully in the hands of Plant Team

Renewable Energy Options

Meeting Energy Requirements through RE

Why RE?

Mandatory

- RPO trajectory announced till 2029-30 (43.33%)
- Separate RPO targets for Wind, Hydro, DRE & other RE

Voluntary

- GBC initiatives for Net Zero, RE100 etc.

Renewable Energy

Offsite RE

Large scale wind/ solar/ hybrid
Biomass & small hydro
Large Biogas/ Bio-CNG/ Green Hydrogen

Onsite RE

Rooftop solar/ wind-solar hybrid/ BIPV
Ground mounted solar
Solar thermal
Biomass/ Small biogas

Business Models

Captive/ CAPEX

- Green Open Access Rules: Consumers with > 100 kW load can procure RE power through open access
- RE projects under Captive/ Group Captive mode exempted from cross subsidy & additional surcharges in many States

Group Captive

RESCO/ OPEX/ PPA

Purchase from Energy Exchanges

- IEX, PXIL
- Green Term Ahead Market
- Tariffs: INR 4.68 – 8.39/ kWh in 2023

Purchase of RECs

- IEX, PXIL
- 6 GW registered
- RECs traded at INR 360/ certificate

Purchase from DISCOMs

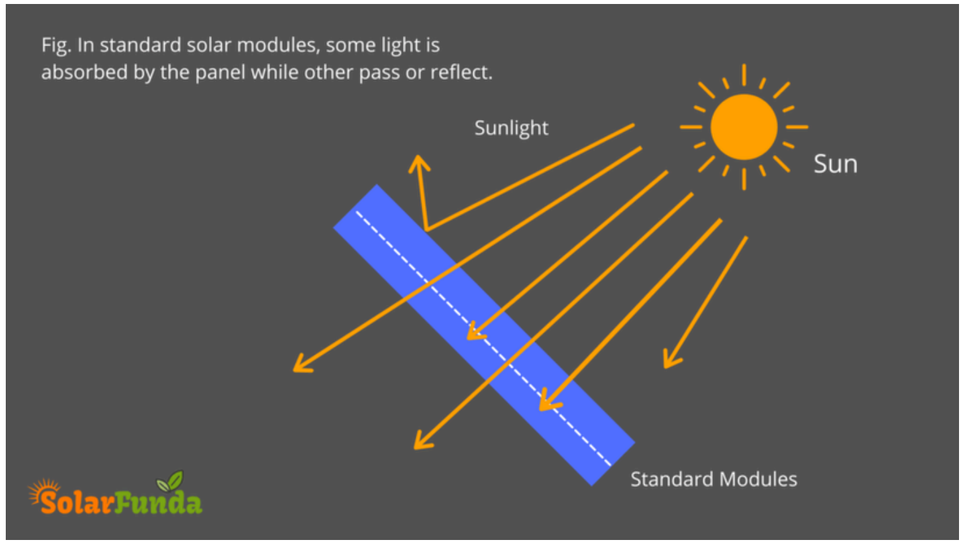
- 15 States have notified
- Tariffs: INR 0.25 – 1.50/ kWh

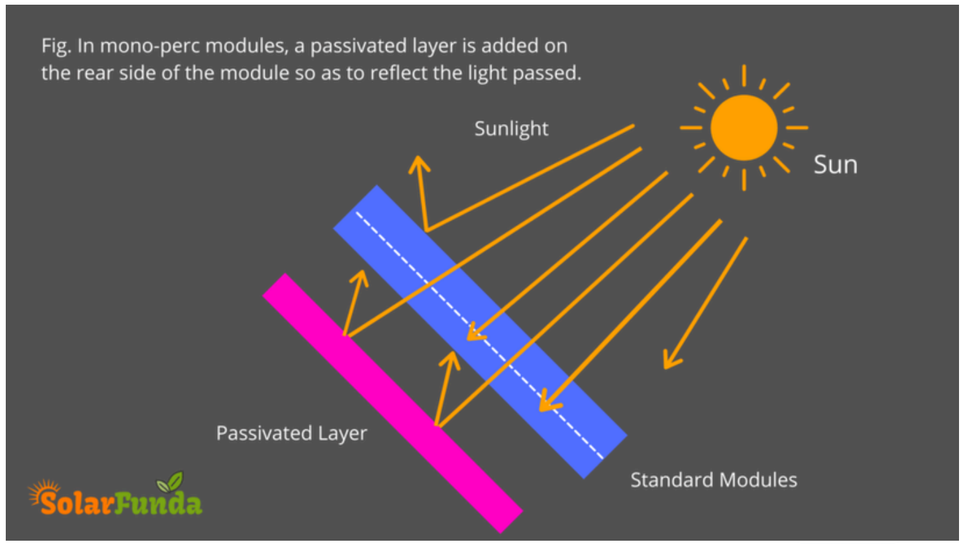
Current Trends in Solar Cell/ Module and Wind Technologies

1. Passivated Emitter Rear Cell (PERC)

- **Passivated layer in the rear of the cell to increase the efficiency of standard solar modules**
- **Light passing through the cells is reflected back by passivated layer -----> increased absorption -------> increased power production**
- **Mono-PERC is popular; though the layer can be added to polycrystalline modules also**
  - **Better performance in low light & high temperature conditions**
- **Efficiency of major Indian Mono-PERC Modules: 20.13% – 21.72%; module capacities available up to 665 Wp**

Commercially Available in India





2. Half Cell Technology

- **Traditional solar modules: 60 cells or 72 cells**
- **Half cell modules: 120 cells or 144 cells ----> Reduced mechanical stress/ micro-cracking; less resistance to flow of electrons; increased photon capture & power generation**
- **Advantages**
  - **Better performance in low-light & high-heat conditions**
  - **More durable & less-prone to cracking**
  - **Reduced risk of hot spots**
  - **2-3% improvement in efficiency**
- **A Study predicts that half cell technology will have 40% market share in 2028, against 5% in 2018**

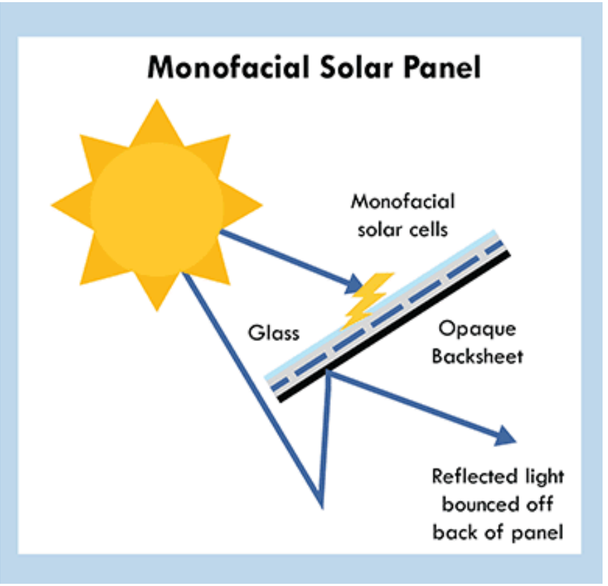
Full cell module

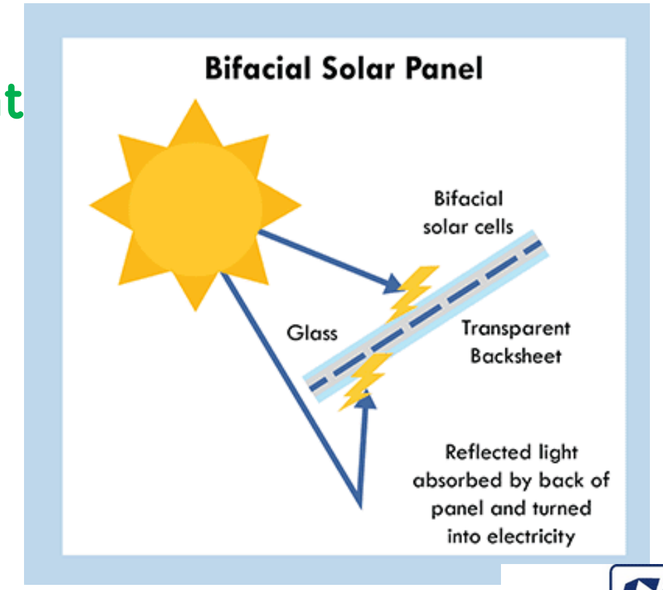
Half cell module

Commercially Available in India

3. Bifacial Solar Modules

- Designed to allow light to enter from both sides of the module leading to higher yield
  - Opaque back sheet is replaced by glass
- Bifacial combined with single-axis tracking can increase solar yield by 40%
- Unique features of bifacial modules
  - Frameless & transparent
  - Back side power rating up to 90% of front side
- How to improve yield further?
  - Elevated structure (20-30% increase with an elevation of 1.5 m)
  - Coating roof surfaces with high Solar Reflective Index (SRI) paint
- Capacities available up to 670 Wp with bifacial rating of up to 70% (module efficiencies range from 20.22% to 27.68%)

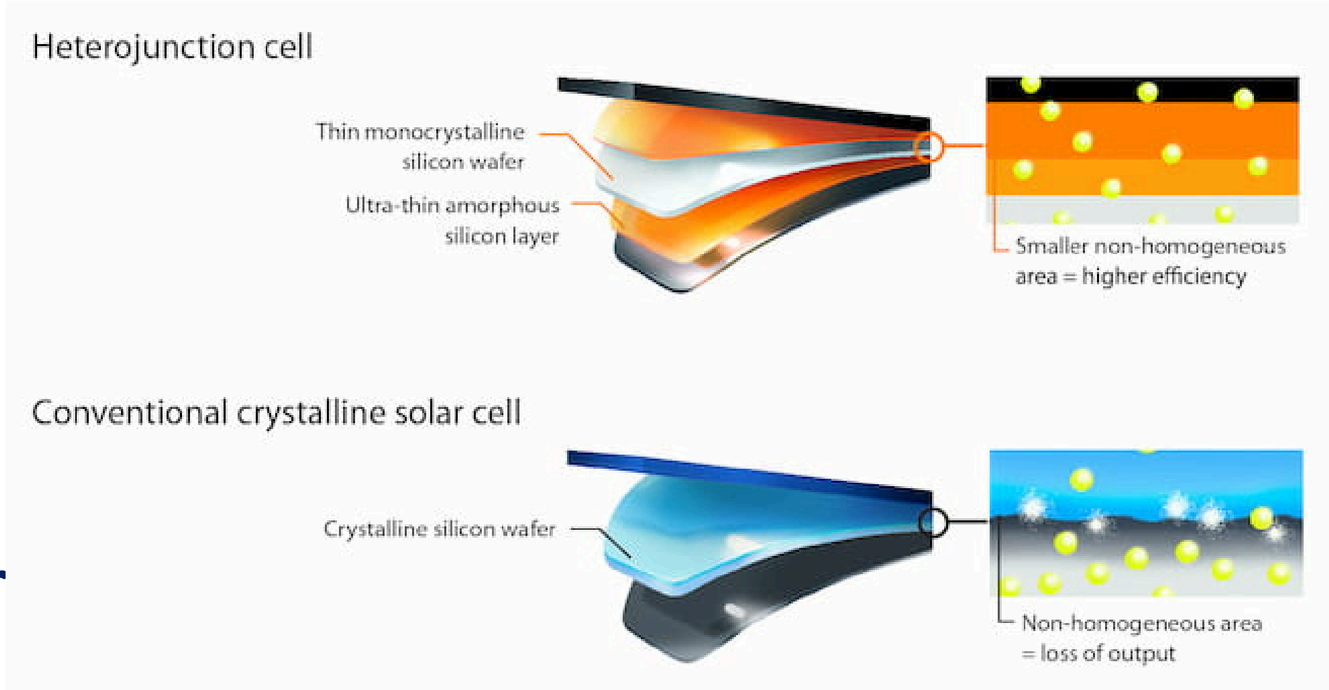




Commercially Available in India

4. Heterojunction Technology

- **Monocrystalline silicon wafer sandwiched between amorphous(thin-film) silicon layers -----> absorbs extra photons**
- **Some manufacturers claim this to be a cost-effective option for performance improvement**
- **Module efficiency: 21% & higher**
- **Improved performance in higher temperatures (lower temp. coefficient)**

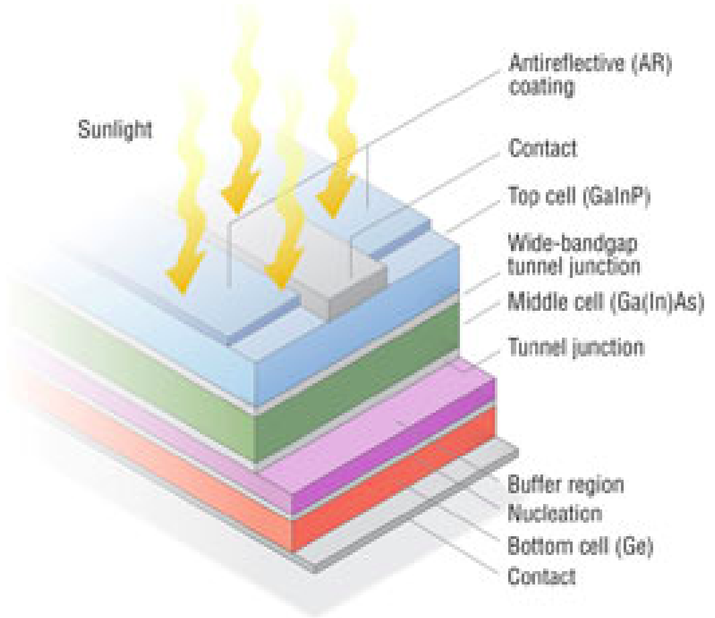


Courtesy – Panasonic

Commercially Available in India

5. Multijunction Solar Cells

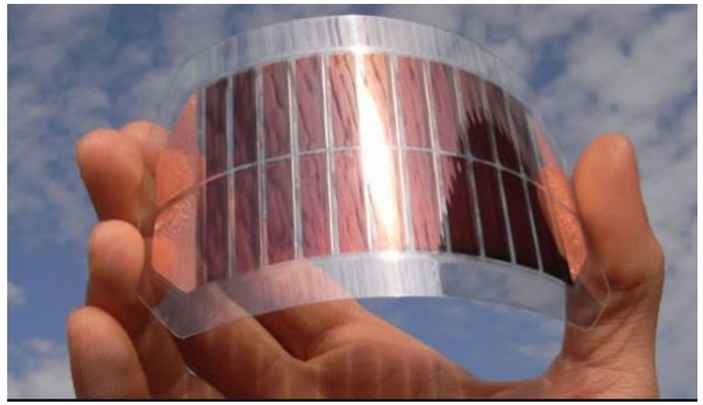
- Capable of better absorption of different wavelengths of sunlight using different layers
- Has multiple p-n junctions (potentially up to 5-6 junctions)
- Semiconductors used in multi-junction solar cells
  - Gallium indium phosphide (GaInP)
  - Indium gallium arsenide (InGaAs)
  - Germanium
- Possible to reach 45% efficiency (theoretical)

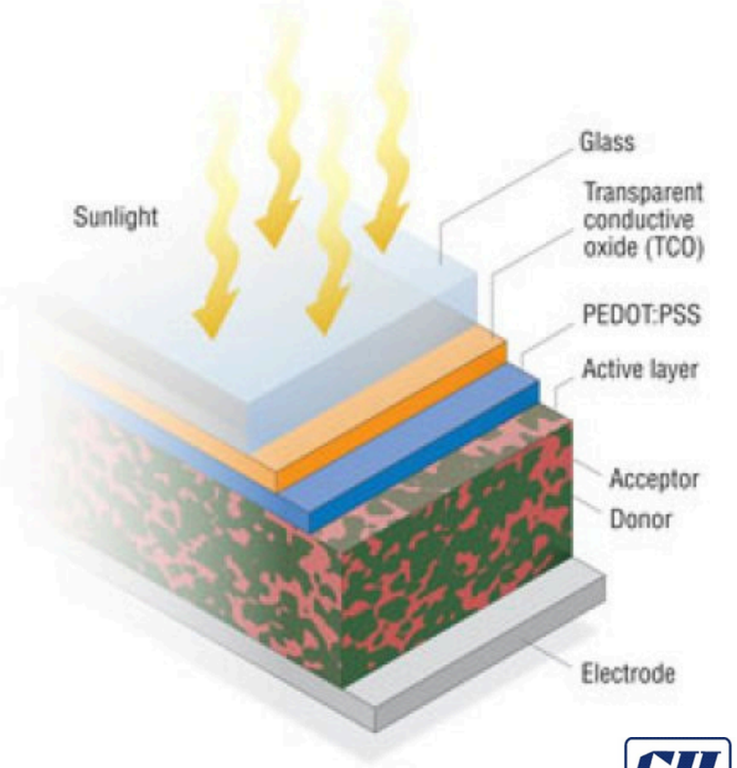


Commercially available; not very popular in India

6. Organic Solar Cells

- Uses organic electronics i.e., conductive organic polymers or small organic molecules to absorb sunlight and generate electricity
- Efficiency: Up to 17% achieved in laboratory scale
- Advantages
  - Low-cost manufacturing
  - Availability of materials in abundance
  - Flexible substrates; having greater potential to cater to BIPV segment
- Barriers
  - Efficiency limitation
  - Long-term reliability

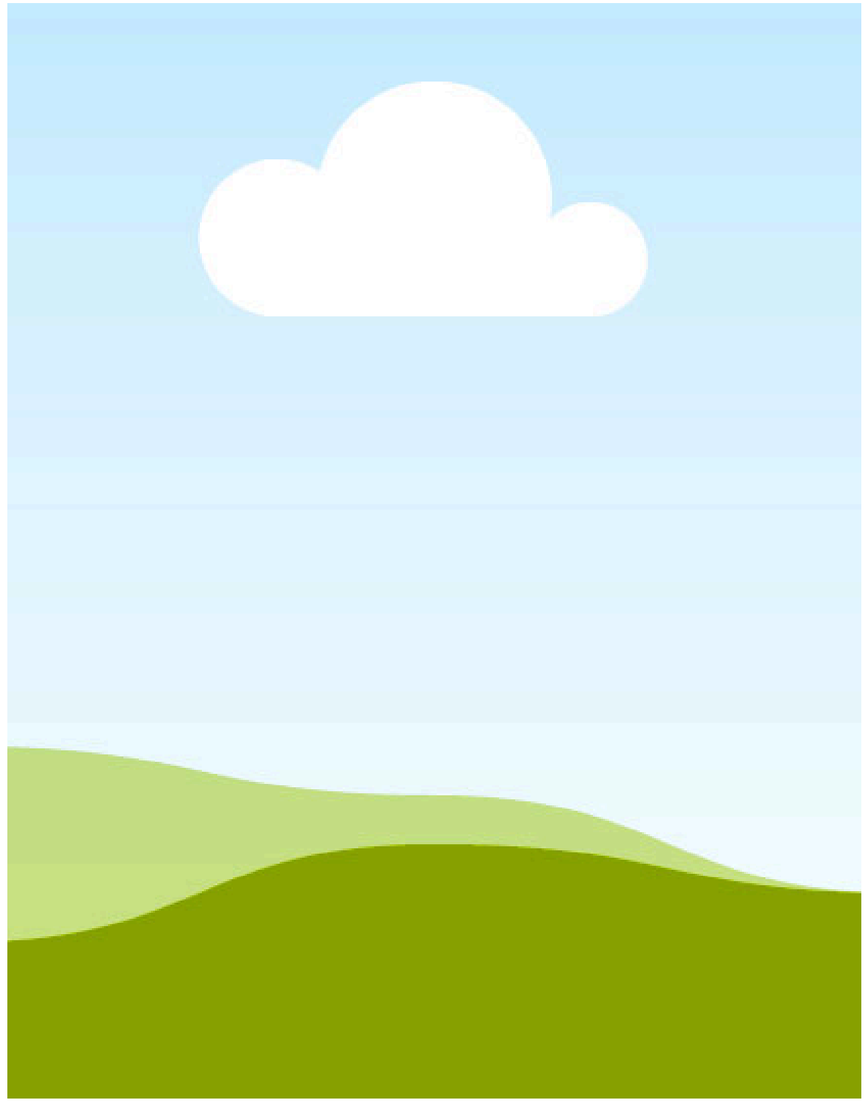




Not yet commercial in India

7. Wind Turbines in India

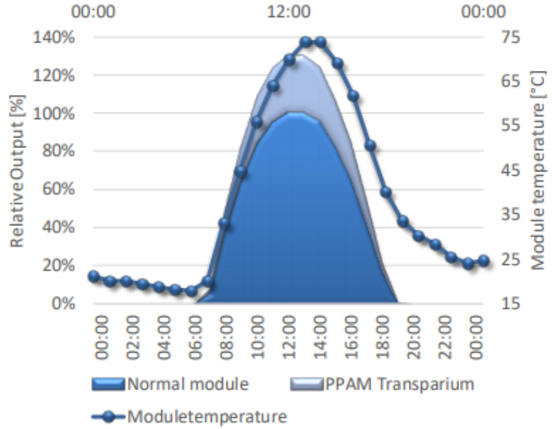
- **10,000 MW of indigenous wind turbine manufacturing capacity**
- **14 companies manufacturing 33 wind turbine models in India**
  - **Capacity (kW): Ranges from 225 kW to 3,600 kW**
  - **Hub height: Varies from 46 m to 160 m**
  - **Tower type: Tubular steel, lattice steel, Tubular reinforcement concrete tower, Conical welded tubular steel tower**
  - **No. of blades: Generally, 3**
  - **Rotor diameter: Varies from 30 m to 156 m**



Case Studies: RE Technologies

Bifacial Solar Modules: Case Study

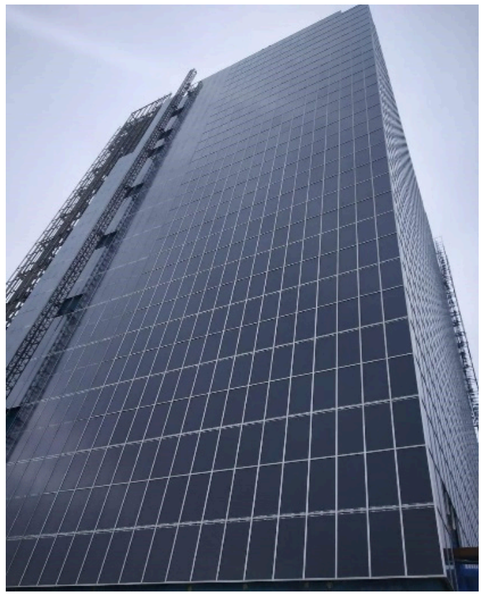
- **CII-GBC is Hyderabad is India's first IGBC Platinum Net Zero Building in India**
- **Capacity: 130 kWp**
- **Power generation: 220,000 kWh/ annum**
- **CO2 emission reduction: 180 tons / annum**
- **Bifacial solar PV modules of 360 Wp & 310 Wp capacities (vertically and horizontally mounted)**
- **Modules placed on trackers**
- **Inverter capacity: 125 kW**



Bifacial solar modules can be explored if more generation is required from limited roof/ ground area

Building Integrated Solar PV: Case Study

- **Capacity: 1 MW**
  - **Replaced glass in the facade with solar modules in existing building**
- **Area: 5,000 sq. ft**
- **Module mounting: Custom designed aluminium rails**
- **Units generated: 593,000 kWh/ annum**
  - **45-50% generation when compared to south facing modules, inclined at an angle equal to latitude of the location**
- **CO_2 emission reduction: 486 tons/ annum**



Courtesy: U-Solar

Building Integrated Solar PV can be explored if more generation is required from onsite sources

Floating Solar: Case Study

- **Capacity: 4.096 MWp DC (3.30 MW AC)**
- **Reservoir Area: 3,600 sq. m**
- **No. of solar panels: 7,600**
- **Annual energy generation: 6,173 MWh**
- **Power usage: Captive**
- **Expected reduction of water evaporation: Up to 70%**
- **CO_2 emission reduction: 6,000 MT/ annum**

Representational Image
Courtesy: Ultratech

No land requirement and also reduces evaporation from water bodies

Performance Improvement of Rooftop and Ground Mounted Solar Plants

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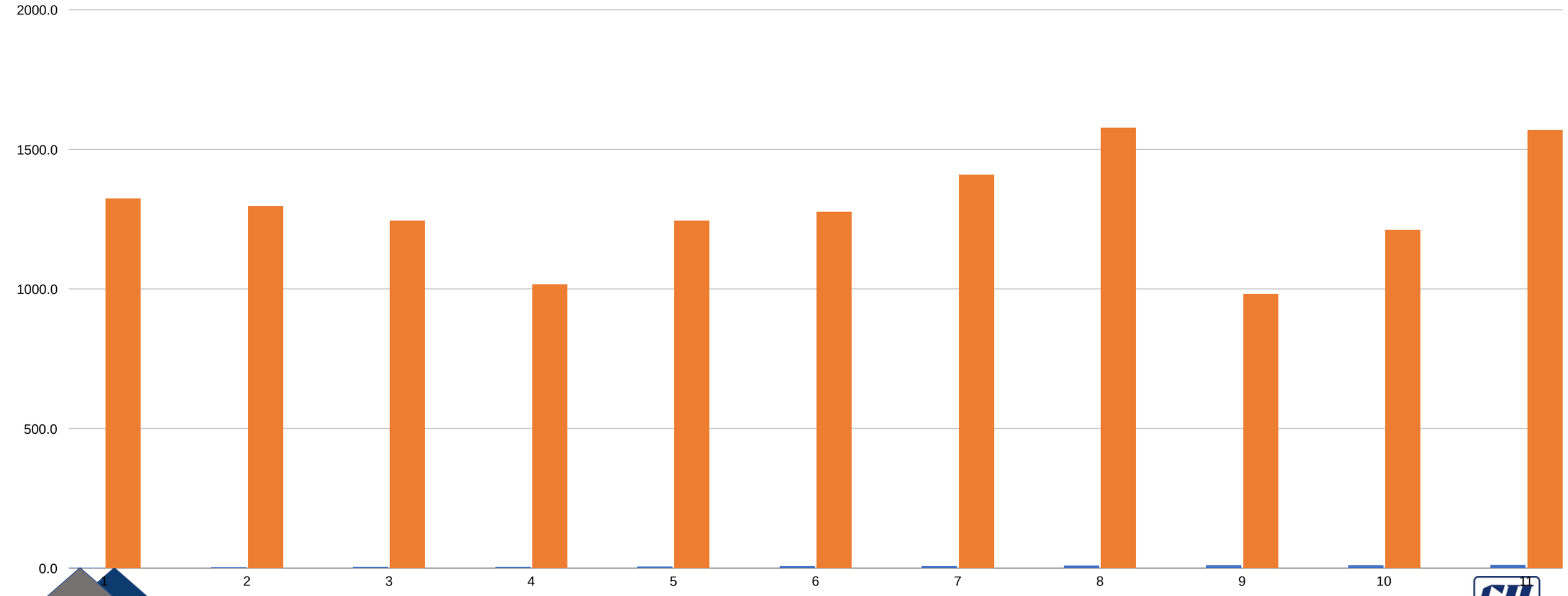
Opportunities for Rooftop Solar Assets

This is extracted from the data provided by rooftop solar plants participated in CII Performance Excellence Awards (capacity ranging from 0.4 MWp to 6.6 MWp)

15 % potential available for performance improvement compared to average

38 % gap between best performing and least performing plants



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Rooftop Solar: Comparison

S. No.	Parameter	System installed with good quality & maintained well	System installed with poor quality & not maintained well
1	Capacity of the System (kW)	100 kW	100 kW
2	Cost* of the System (INR in lakh)	INR 39 lakh	INR 35 lakh
3	Annual solar power generation (lakh kWh/ annum)	1.40 lakh units/ annum (CUF – 16%)	1.22 lakh units/ annum (CUF – 14%)
4	Loss in generation (kWh)	Nil	**0.18 lakh units/ annum**
5	Monetary loss (INR in lakh)	Nil	**INR 1.22 lakh/ annum (INR 30 lakh for 25 years)**
6	Issues	Nil	• Increased downtime • Frequent component replacement • Generation loss • Fatal accidents

*Market trends

Quality makes business sense; up to 20% improvement in system performance

CII's Rooftop Solar Vendor Rating Program

- **VRP is aimed at improving quality, safety & performance of rooftop solar installations in India, by creating a network of high-quality and high-performing vendors**

102 vendors from 18 states certified so far

S. No.	Category	No. of Certified Vendors	Remarks
1	**Large** (> 250 kWp RTS capacity)	53	National – 18 Regional – 17 State – 18
2	**Medium** (10 – 250 kWp RTS capacity)	43	National – 1 Regional – 14 State – 28
3	**Small** (< 10 kWp RTS capacity)	6	National – 1 State – 5
Total		**102**	

VRP: Benefits to Other Stakeholders

Consumers – Commercial/ Industrial/ Residential

- Identify high quality vendor
- Compare vendors based on rating
- Enhanced system performance
- Increased reliability
- Expected return on investment or even better rate of return

Bankers

- Record of quality of vendors & systems
- Assurance of performance of systems and better return
- Faster loan approval process
- Potential reduction in interest rates
- Increase the confidence in RTS

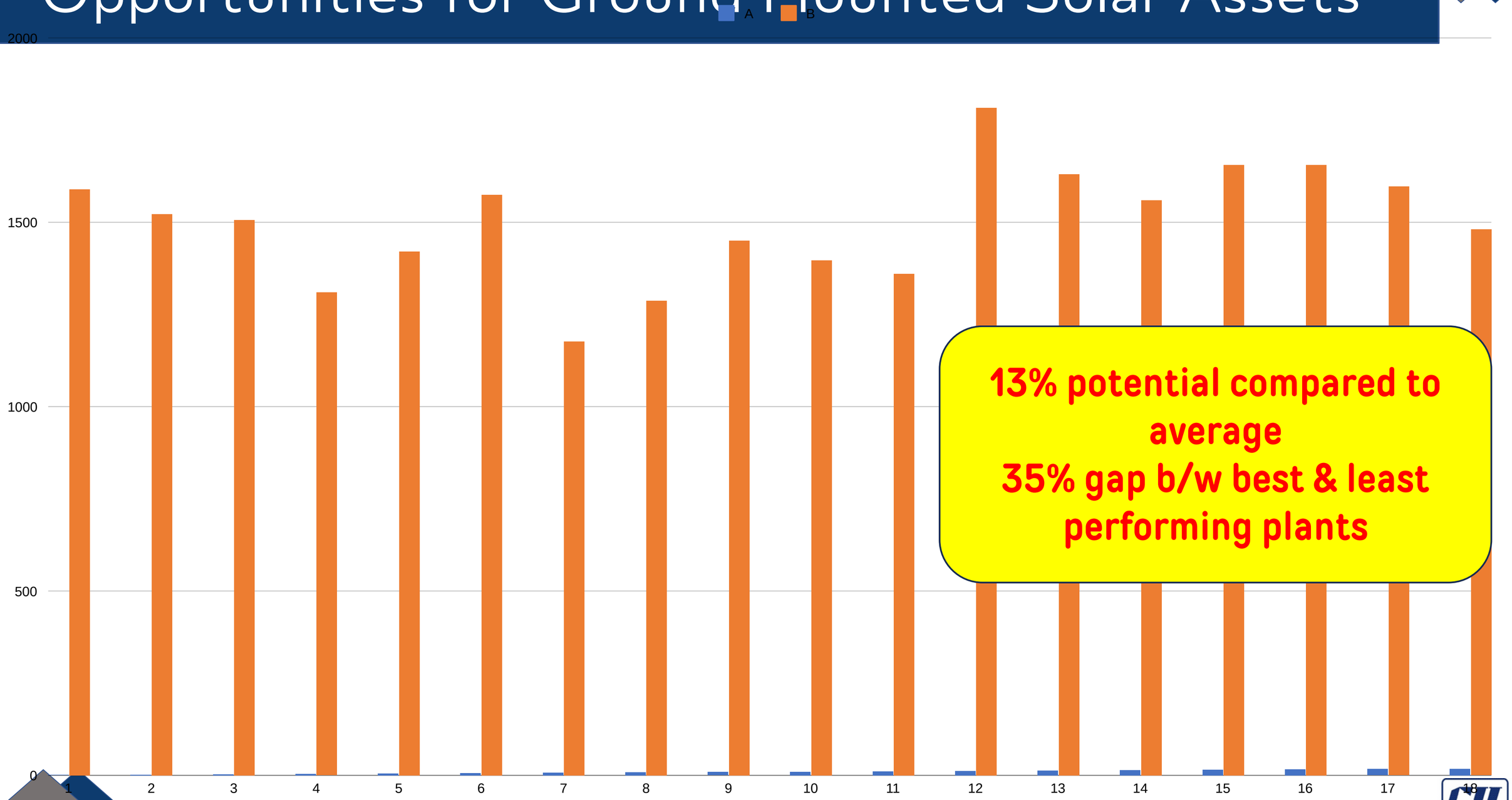
Utilities

- Enhanced safety due to improved compliance by installers
- Improved quality resulting in increased predictable generation, allowing better demand/grid management

Large Developers

- Identify quality vendors (EPC/installers)
- Increase / enhance returns through improved performance
- Reduce transaction costs

Opportunities for Ground Mounted Solar Assets



Ground Mounted Solar Plants
Best Practices & Case Studies

Best Practices : 10 MW Solar Plant in Cement Plant in Andhra Pradesh

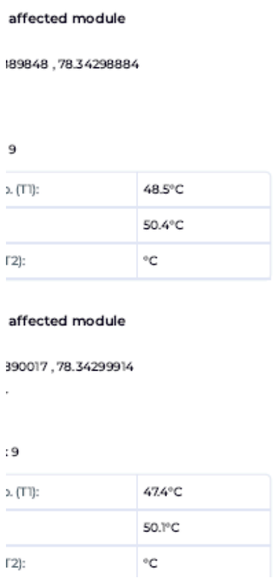
- Soiling-loss based cleaning of modules
- Semi-automatic module cleaning (wet cleaning)
- SCADA based data acquisition and reporting
- Realtime monitoring of string and inverter performance
- Module to module earthing
- Preventive maintenance
  - Cleaning of inverter filter (weekly) and replacement of filter (half yearly)
  - Check-up of transformer (monthly)
  - Proper cable management (as required)
  - Thermography of modules (as required)
  - Pyranometer (cleaning every two days and calibration once in a year)

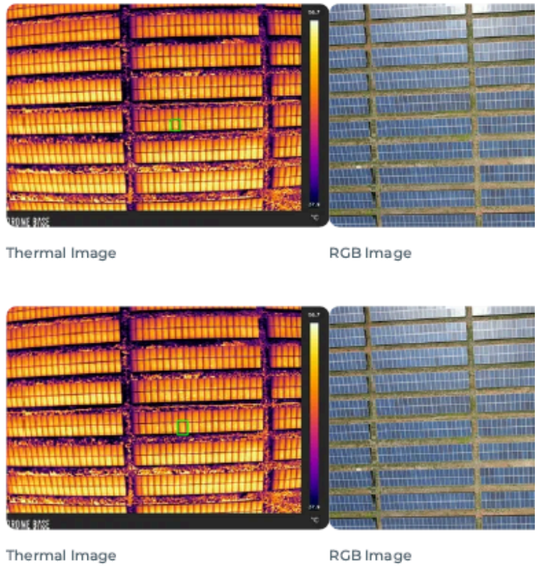
Best Practices : 10 MW Solar Plant in an Airport in South India

- Optimizing operation of Inverter exhaust fan
- Maintenance of Pyranometer/ Weather Monitoring Station & calibration
- Fully automated system for data acquisition and reporting including SCADA
- Realtime monitoring of string and inverter performance
- Deployment of Electric Vehicle (EV) and Rainwater Harvesting System
- Proper Waste and Vegetation management
- Preventive maintenance
  - Modules (thermography on yearly basis), cable management (yearly), module mounting structure tightness (half yearly), SMBs, inverter, transformer & isolator (every month) & inverter fan filter (fortnightly)

Case Study 1: Drone Thermography

- **Drone Thermography (PV Modules, Transmission Lines & Switchyard) – Case Study (50 MW Plant in Tamil Nadu)**
  - On an annual basis, drone thermography shall be implemented on PV Field, Transmission Lines and Switchyard to ensure the healthiness of the System
  - Drone is deployed to inspect the systems at a high level; helps to optimize the operation for anomalies and understand the damages more efficiently through aerial-thermal photographs/ images.
  - **Reduces inspection time by up to 95%**, when compared to manual inspection of PV modules, towers. Reduces labour costs significantly. In FY 21-22, this plant **saved approx. 350 MWh (INR 25 Lakhs) because of proactive measures taken with inputs from drone thermography**.
- **PV Modules: Unhealthy Factors (Fault Description)**





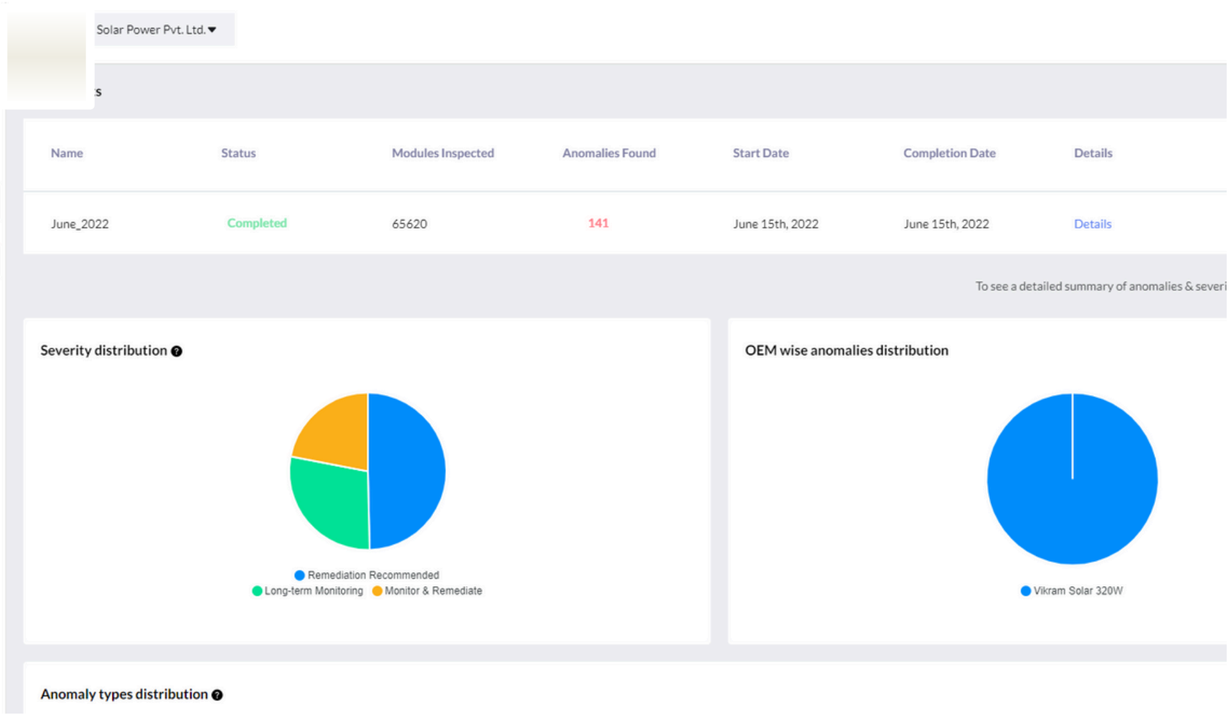
	Module Count	Loss Factor (%)
	148	10
	289	20
	56	30
	261	100
	6	30
		Total approx. power loss (W)
		Total approx. power loss (kW)
		Total approx. power loss (MW)

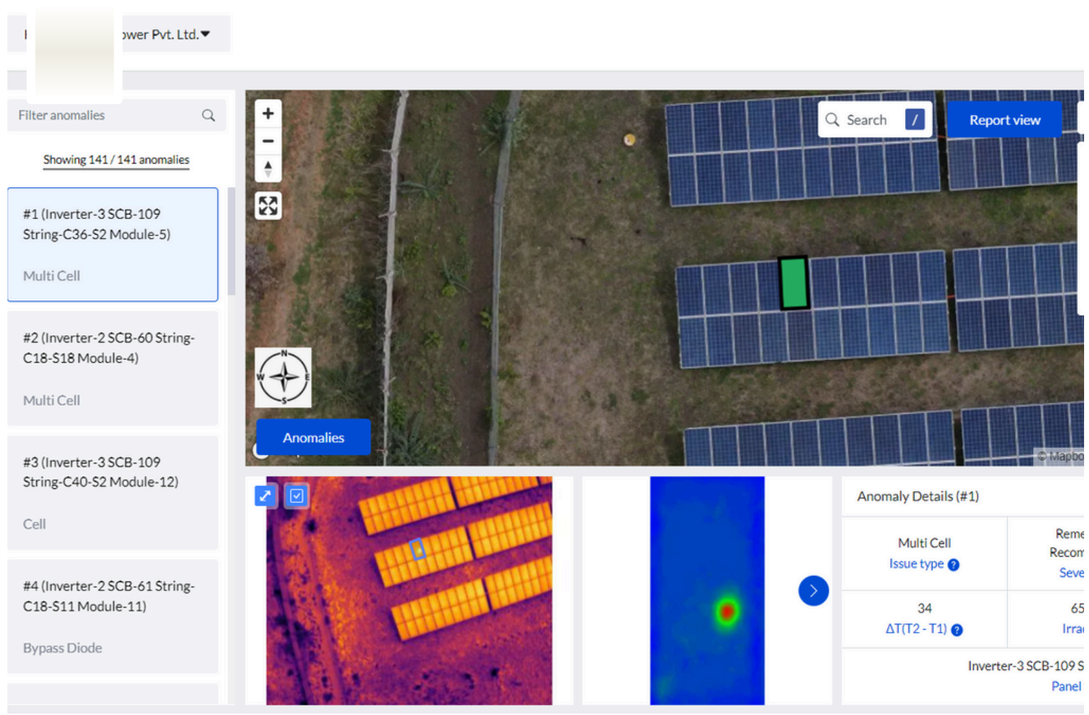
50 MW plant in Tamil Nadu

Case Study 2: Module Thermography & IV Testing

Module Thermography and IV Curve Testing (Case Study: 15 MW plant in Karnataka)

- Conducting drone-based module thermography and IV curve testing annually
- Third-party agency conducts the testing, and the data can be accessed on the portal provided by this agency
- Test results can be compared year on year





15 MW plant in Karnataka

Case Study 3: Robotic Module Cleaning

<u>Robotic module cleaning increases generation by up to 1.5% and reduces O&M cost by up to 20%</u>

Many power plants have implemented robotic module cleaning (semi-automatic/ automatic coupled with wet/ dry) and has reaped benefits

Case Study: 15 MW plant in Karnataka

- This plant is using semi-automated robots for module cleaning
- With the help of bridge connectors, the plant is able improve cleaning efficiency; reduce changes of part failures, reduces stress on labours and increased power generation
- Achieved savings of above **INR 16 lakhs**

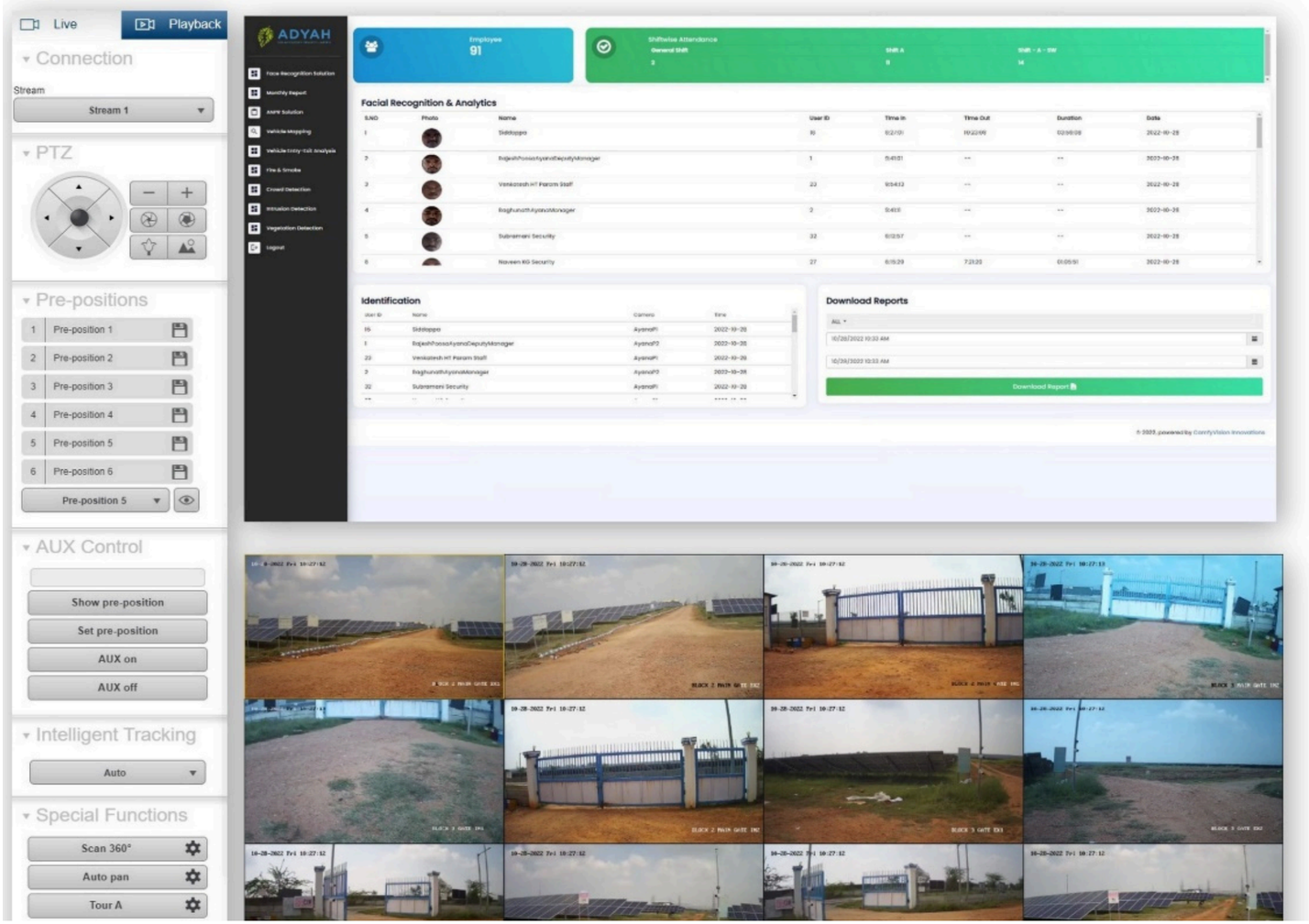
Module Cleaning under progress

Bridge connectors between two tables

15 MW Plant in Karnataka

Case Study 4: Security & Site Monitoring

- **Digital image/ video analytics provides solutions such as intelligent facial recognition based security & attendance solution, AI based fire & smoke detection solution, perimeter/ boundary protection, vehicle movement/ management solutions, activity analysis and instant alerts & customised reports**



300 MW Plant in Karnataka

Case Study 5: Digital Image Analytics

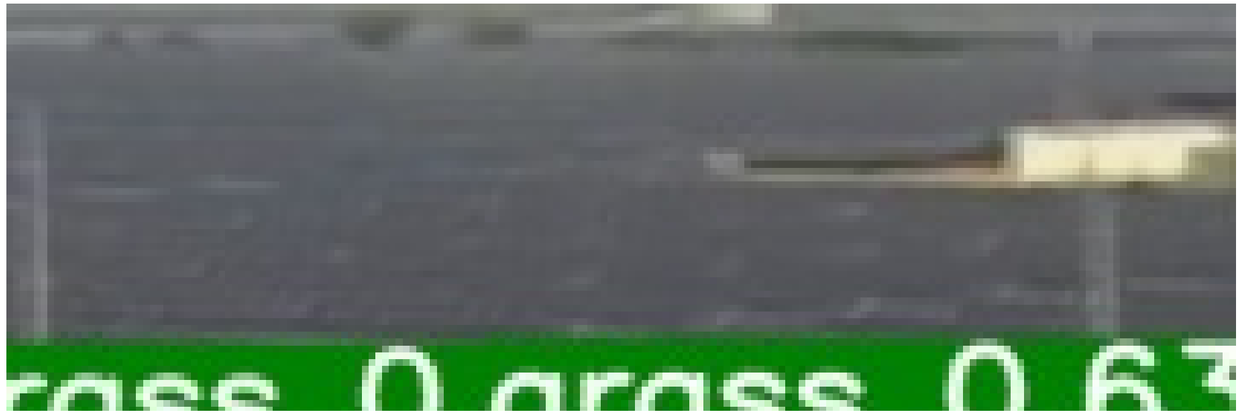
- **Live Site Team Attendance, Live Fire Alarm, Vehicle Tracking, Motion Detection Tracking, Alarms/ Alerts, Digital Geo-fencing**

Vehicle Details

S.NO	Photo	Owner	LP Number	Time In	Time Out	Duration	Date
1	KA06AA3623	Ayana	KA06AA3623	10:40:26	11:25:57	00:45:31	28/10/2022
2	KA643811	Ayana	KA643811	9:24:51	10:47:34	01:22:43	28/10/2022
3	KA643846	Ayana	KA643846	8:59:17	9:52:00	00:52:43	28/10/2022
4	KA643847	Ayana	KA643847	9:17:39	10:42:43	01:25:04	28/10/2022
5	KA643875	Ayana	KA643875	9:28:52	10:42:36	01:13:44	28/10/2022

Facial Recognition & Analytics

S.NO	Photo	Name	User ID	Time In	Time Out	Du
1		Siddappa	16	6:27:01	10:23:09	03
2		RajeshPoosaAyanaDeputyManager	1	9:41:01	--	--
3		Venkatesh HT Param Staff	23	9:54:13	--	--
4		RaghunathAyanaManager	2	9:41:11	--	--
5		Subramani Security	32	6:12:57	--	--



300 MW plant in Karnataka

Net Zero Energy Roadmaps for Industry

Working with leading PSUs & corporates and supporting them in their RE/ net zero energy journey

- **Technology Evaluation & Comparison**
- **Financial Analysis & Business Modelling**
- **Policy Analysis & Facilitation**
- **Vendor Selection & Deal Facilitation**
- **Feasibility Study/ RE/ Net Zero Strategies & Roadmaps**

Learnings from Net Zero Energy Studies:

1. Different business models are to be explored for becoming 100% RE (however, there are some policy related challenges)
2. Energy storage is slowly becoming an integral part for meeting industrial energy requirements
3. Existing RE assets have either not been designed or utilized properly (scope for performance improvement)

We can develop roadmaps/ strategies for becoming net zero energy/ 100% RE; provide state-wise/ sector-wise support for RE procurement

Green Power & Performance Excellence Awards

- **Green Power Conference & Exposition: Flagship Annual Conference of CII on RE, conducted since 2002**
  - 10+ thematic sessions on various RE topics
  - 500+ participants, including Senior Govt. and Industry Participation
  - 50+ speakers
  - 23rd edition in Chennai on 20th & 21st November 2024
- **Performance Excellence Awards for Solar, Wind & Hybrid Plants (6th edition in 2024)**
  - Categories: Ground Mounted Solar, Rooftop Solar, Floating Solar, Wind, Wind-Solar Hybrid
  - 100+ plants awarded over the last 5 editions for their excellence & leadership in

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What can Chemical and Pharmaceutical Industry

- **Develop a net zero/ decarbonisation roadmap with long-term and medium-term targets**
- **Adopt latest RE technologies to reduce carbon footprint**
- **Improve the performance of existing solar assets**
- **Participate in CII Performance Excellence Awards for Solar, Wind and Hybrid Plants and learn from the best performing plants**
- **Utilise the services of 100+ CII Certified Rooftop Solar Vendors for your rooftop/ solar requirement**

CII will be glad to support the Industry in all these activities

For more details, please contact
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