
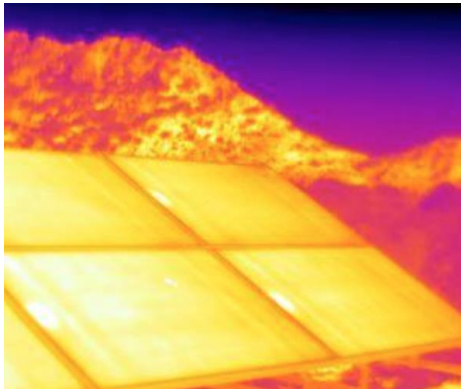
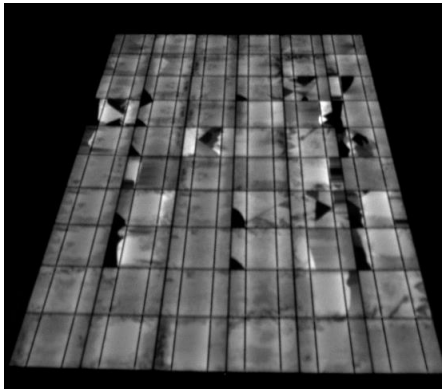


# Module Reliability Group

## Presentation for Industry-Academia Meet
## January 13, 2017


**National Centre for Photovoltaic Research and Education**

Indian Institute of Technology Bombay

# Module Reliability Group

- Faculty:
  - J. Vasi, A. Kottantharayil, B.M. Arora, P. Bhargava, S. Mallick, A. Singh, B. Kavaipatti, S. Mahapatra, L. Kazmerski (Visiting), R. Arya (Visiting)

- Staff and Students:
  - H. K. Singh, A. Sinha, R. Kumar, R. Dubey, S. Chattopadhyay, V. Kuthanazhi, S. Warade, S. Bhaduri, S. Zachariah, P. Pillai, Deven P. V., A. Alath, S. Rambabu

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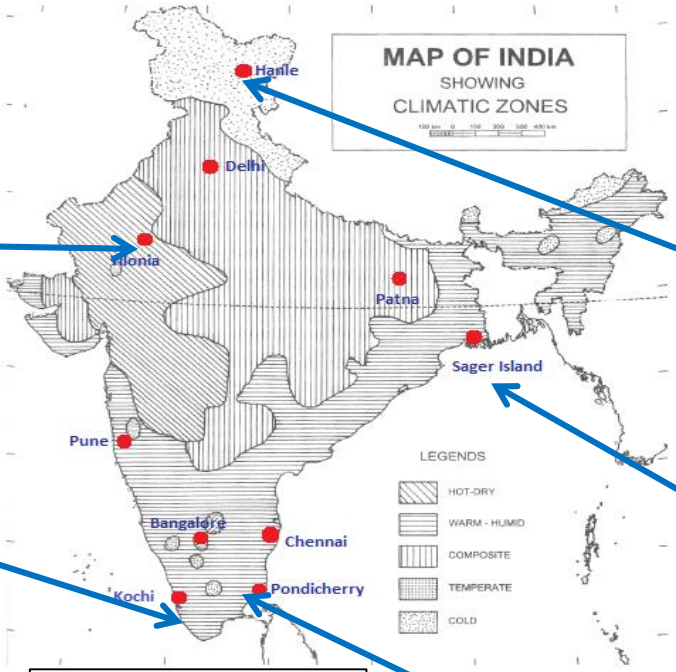
# Module Reliability Activities at NCPRE

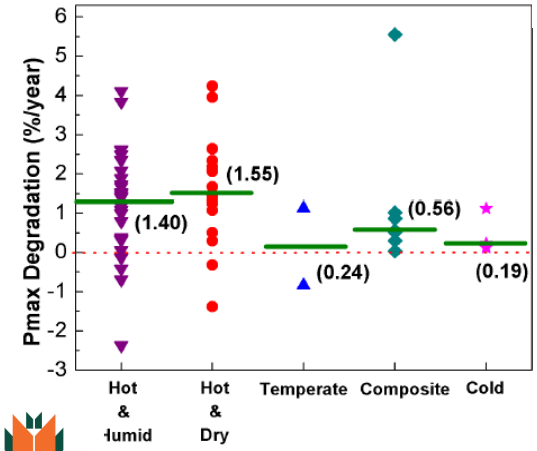
- Study of PV module performance and reliability
- Physical mechanisms – why do modules degrade?
- Soiling studies
- Module characterization
- Electroluminescence techniques
- Hot climate effects
- Performance loss due to transportation and installation
- Accelerated test models
- Module deployment considerations
- “All-India Survey of PV Module Reliability” (jointly with NISE)

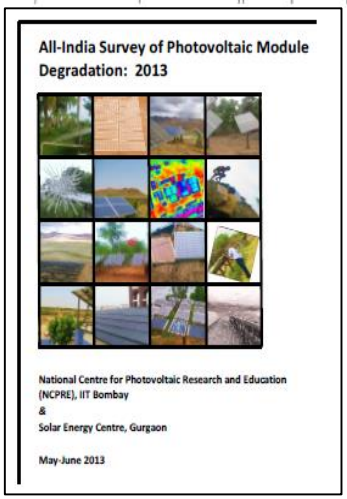
# Module Reliability Deliverables for NCPRE Phase II

- Field assessment of PV module reliability in India – 2016, 2018, 2020
  - Creation of extensive data base for climatic & technology variation
- Survey of large power plants (with power group)
  - Study of BOS performance, energy output, PR, CUF
- Development of module degradation models and module accelerated testing
  - Emphasis on hot and humid climates
- Module material quality assessment and testing
  - Emphasis on EVA, backsheet, etc.
- Development of new field characterization techniques, and transfer to industry
  - Will help to ensure good quality and performance in field

# All India Survey of PV Modules 2013





All-India Survey of Photovoltaic Module Degradation: 2013

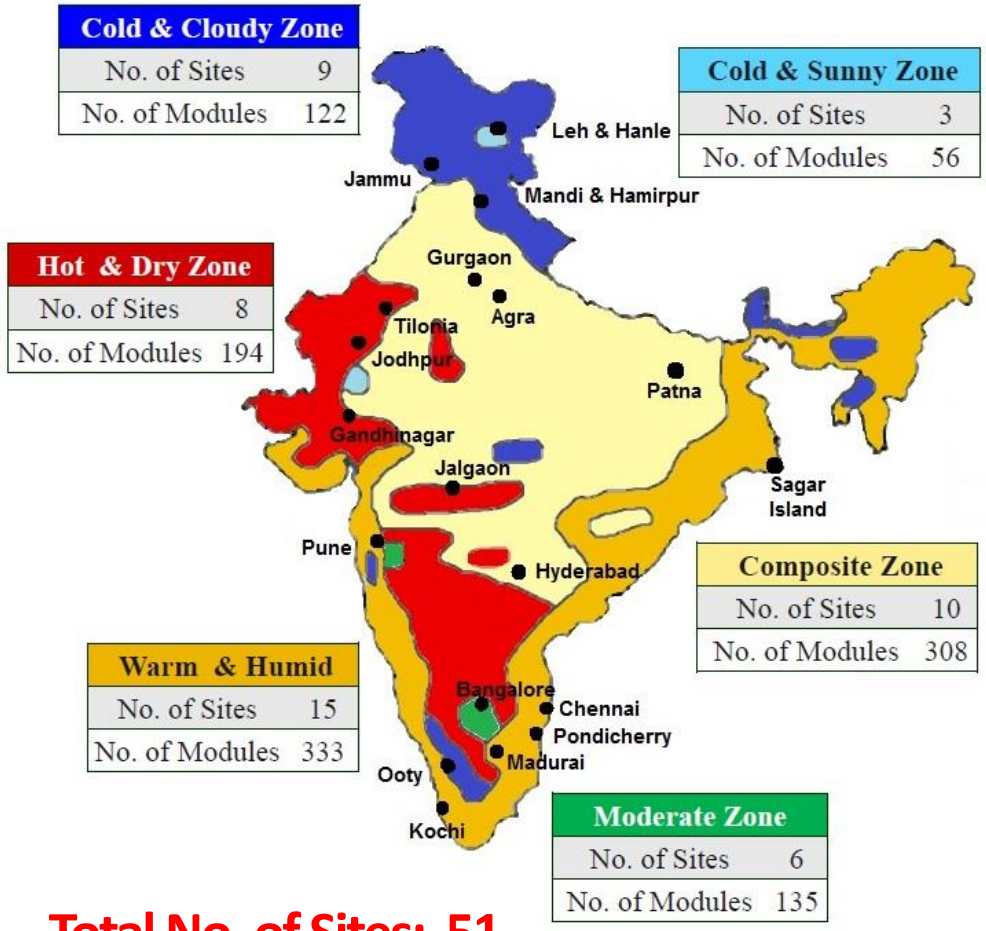
National Centre for Photovoltaic Research and Education (NCPRE), IIT Bombay
&
Solar Energy Centre, Gurgaon

May-June 2013

***Download report from***

***http://www.ncpre.iitb.ac.in/uploads/All_India_Survey_of_Photovoltaic_Module_Degradation_2013.pdf***

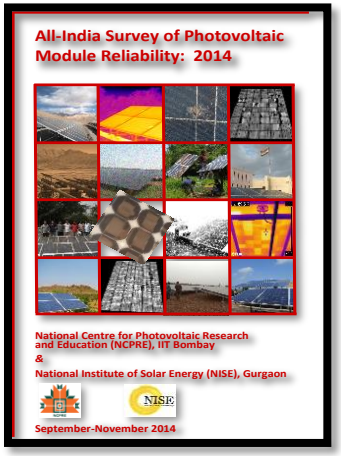
# All India Survey of PV Modules 2014




**Total No. of Sites: 51**

**Total No. of Modules: 1148**

| Characterization Techniques Used |
|---|
| Illuminated *I-V* and Dark *I-V* tracing |
| Illuminated IR and Dark IR imaging |
| Daylight Electroluminescence imaging |
| Interconnect failure test |
| Insulation resistance test |
| Visual degradation checklist |
| Inverter performance test |
| Socio-economic checklist |




***Download report from***

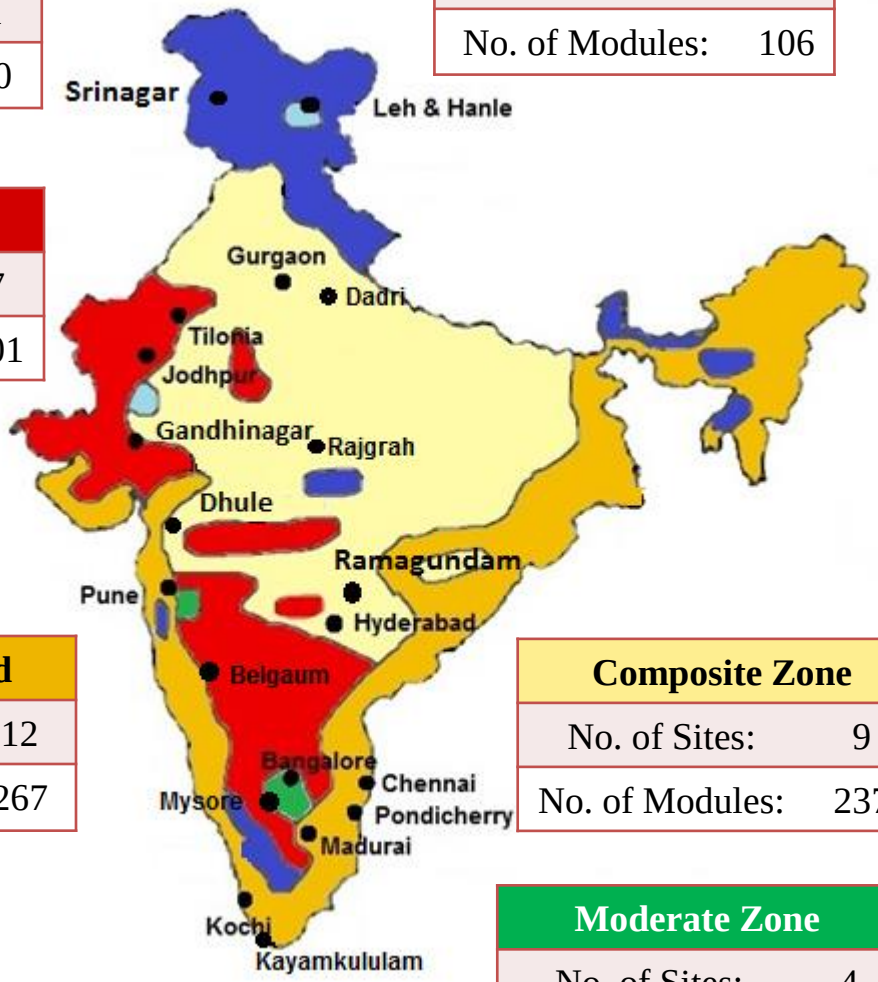
***http://www.ncpre.iitb.ac.in/uploads/All_India_Survey_of_Photovoltaic_Module_Reliability_2014.pdf***

# All India Survey of PV Modules – 2016

| Cold & Cloudy Zone | |
|---|---|
| No. of Sites: | 1 |
| No. of Modules: | 20 |

| Cold & Sunny Zone | |
|---|---|
| No. of Sites: | 4 |
| No. of Modules: | 106 |

| Hot & Dry Zone | |
|---|---|
| No. of Sites: | 7 |
| No. of Modules: | 201 |




| Warm & Humid | |
|---|---|
| No. of Sites: | 12 |
| No. of Modules: | 267 |

| Composite Zone | |
|---|---|
| No. of Sites: | 9 |
| No. of Modules: | 237 |

| Moderate Zone | |
|---|---|
| No. of Sites: | 4 |
| No. of Modules: | 94 |

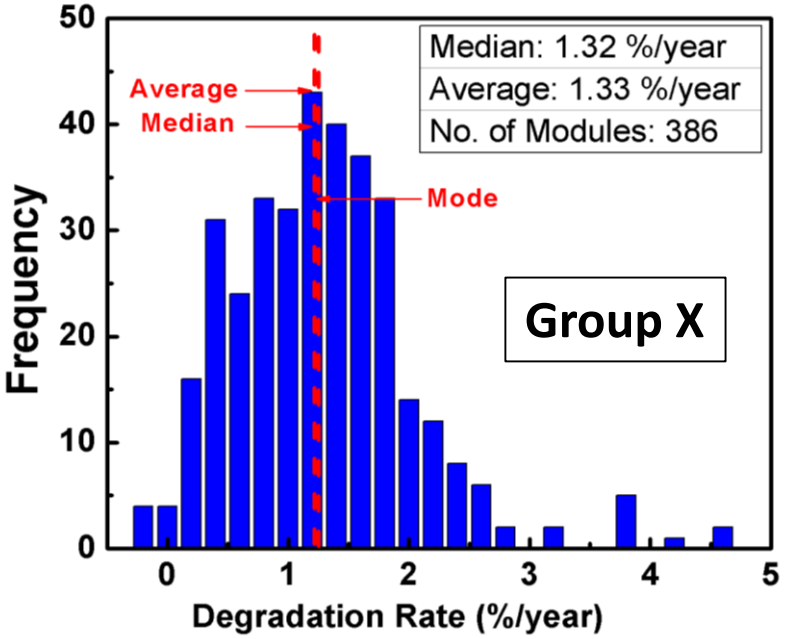
**Total No. of Sites: 37**

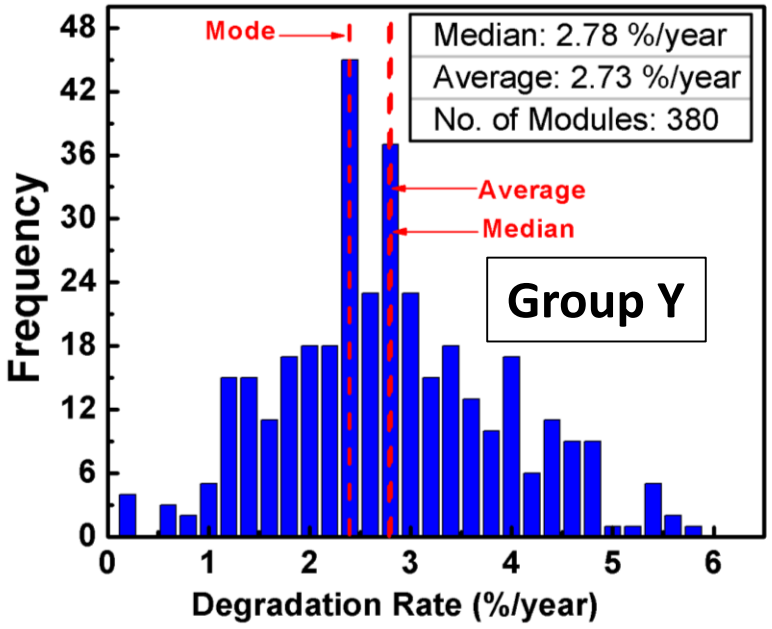
**Total No. of Modules: 925**

| Characterization Techniques Used |
|---|
| Illuminated *I-V* and Dark *I-V* tracing |
| Illuminated IR and Dark IR imaging |
| Daylight Electroluminescence imaging |
| Interconnect failure test |
| Insulation resistance test |
| Visual degradation |
| Inverter performance test |
| Socio-economic checklist |
| On-site temperature co-efficient measurement |

# Survey Team and Equipment

# Power Degradation Rates for Modules in Group X and Group Y Sites




- **Group X** sites are quite good ~ **1.3%/year**
- **Group Y** sites are cause for concern ~ **2.7%/year**
- Differences may be due to **module quality**, and also **installation practices**

# Assessing Rooftop Solar Potential in Mumbai

(in collaboration with IEEE, ORF, C-USE, and BTI)

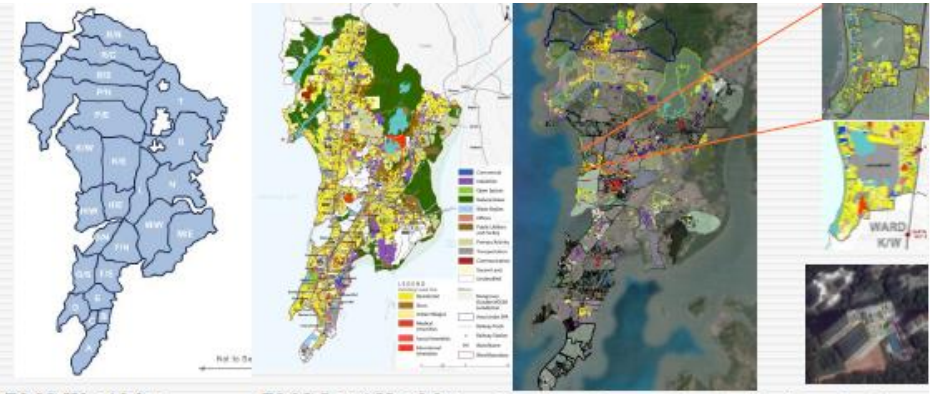
**Objective:**

To assess the **rooftop PV installation potential for Greater Mumbai** Region (BMC)

**Methodology:**

- Rapid Hierarchical mapping of rooftop areas using free online **GIS tools** (Google Earth Pro, Wiki Mapia, Solarmapper etc.)
- Developing **probability indices and conversion ratios** from plot areas to built areas to shade-free areas using BMC existing land use maps as references.
- Work done by nearly **120 students** from 12 IEEE Bombay student branches under NCPRE guidance
- Primary Level **Categorisation of Buildings**: *Residential, Commercial, Industrial, Offices, Education Amenities, Transportation, Medical*

- **Workshops held at NCPRE**: 1 introductory workshop, 3 hands on training of GIS tools for team leaders, rooftop survey at IITB buildings
- **GIS:** More than 9500 plots mapped. 120 million sq. m area mapped. Nearly 30 % of BMC area
- **Site Surveys:** 49 buildings across 24 wards
- **3-D Modelling of Buildings:** In progress
- **Estimated Potential: 1.5 GW**

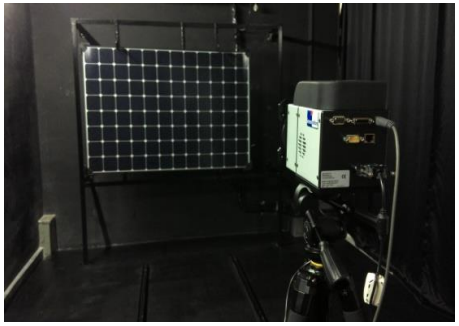


BMC Ward Map | BMC Land Use Map | Mapping done on Google Earth by Students

IEEE BOMBAY SECTION | OBSERVER RESEARCH FOUNDATION | NCPRE | C-USE Centre for Urban Science and Engineering | BRIDGE TO INDIA

# Facilities in Module Reliability Lab


*Module Tester*



*Electroluminescence Unit*


*Portable IV Tester*

*Cell Line Checker*

*Environmental Chamber*


*IR Camera*

*Multi-IV Tester*

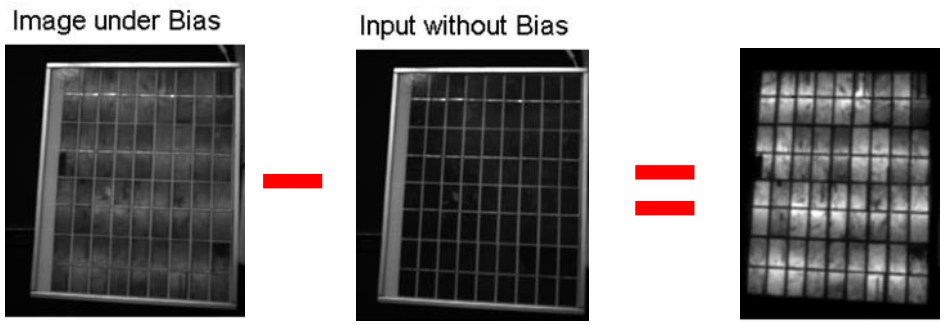
*Sun Path Finder*


*Colorimeter*

NCPRE

# Daylight EL developed at IITB

**Outdoor EL Setup**

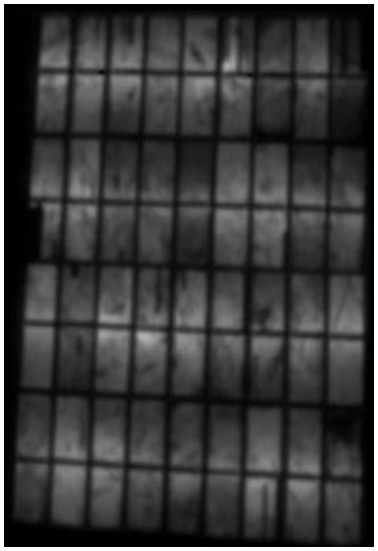


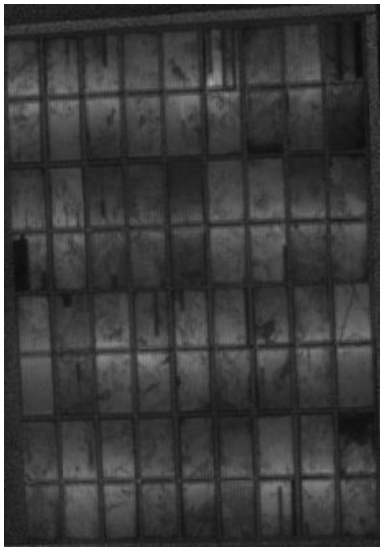

**Daylight EL Methodology**

**Module Images**

*Left*: Standard Dark Room Image

*Right*: Image taken outdoors using image processing





# Industry Interaction Possibilities

- Module characterization and testing
- Materials quality characterization
- Performance assessment of fielded modules
- Degradation assessment of modules
- Power plant performance assessment
- Commercialization of module testing equipment

***Target industries:***

- *Module manufacturers*
- *PV materials and cell manufacturers*
- *Power plant developers and operators*
- *Finance and insurance companies*
- *Instrument developers*

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# Upcoming Workshop

**“Assessing Performance of PV Modules in the Field”**

**Dates: April 6-7, 2017**

**Venue: VMCC, IIT Bombay**

This workshop will provide detailed procedures to study fielded PV modules. A variety of techniques to assess their performance will be presented, and also methods to locate defects, analyse degradation, and estimate their durability. The workshop will include a ‘hands-on’ session as well.

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# Acknowledgments

Ministry of New and Renewable Energy (MNRE), Government of India, is gratefully acknowledged for funding NCPRE and the Survey.