NISE
National Institute of Solar Energy









ANNUAL REPORT 2015-16

National Institute of Solar Energy

NISE
National Institute of Solar Energy

National Institute of Solar Energy

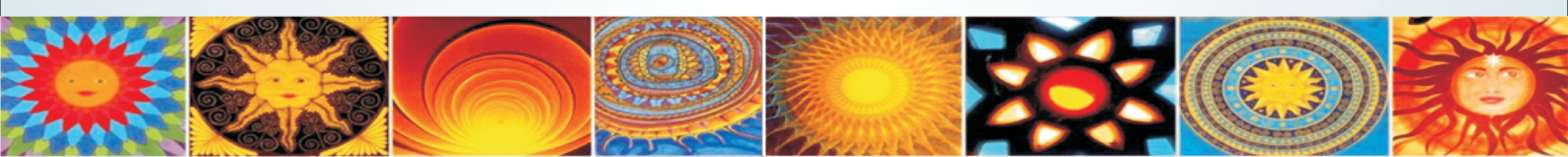
(An Autonomous Institute of Ministry of New and Renewable Energy)

Gurgaon-Faridabad Road, Gwalpahari, Gurgaon - 122003 (Haryana)
www.nise.res.in

ANNUAL REPORT
2015-16

NISE
National Institute of Solar Energy

National Institute of Solar Energy (NISE)
(An Autonomous Institute of Ministry of New and Renewable Energy)
Gurgaon- Faridabad Road, Gawalpahari – 122003 (Haryana)
www.nise.res.in



CONTENTS

OVERVIEW i

ADMINISTRATION v

Chapter-1: Solar Photovoltaic Division 1
1.1 Photovoltaic Test Facility 1
1.2 Power Electronics Lab 16
1.3 Battery Characterization Lab 19
1.4 SPV Lighting Systems Laboratory 23
1.5 Solar Cell Characterization and Outdoor Module Testing Group 31
1.6 Solar PV Water Pumping Division 45
1.7 New Test Characterization Facilities 50
1.8 Solar Design Simulation Lab 52

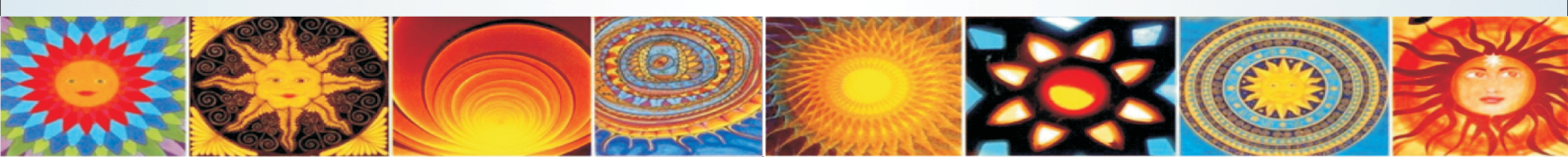
Chapter-2: Solar Thermal & Resource Assessment Energy Division 61
2.1 On-going R&D Projects 61
2.2 In House Research and Development Activities 67
2.3 Solar Thermal Testing Facilities for Concentrated Solar Thermal and Solar Water Heating Systems 70
2.4 Solar Radiation Resources Assessment (SRRA) 76

Chapter-3: Skill Development & Consultancy Division 79

Chapter-4: Hydrogen Energy & Fuel Cell Division 106

Chapter-5: R&D Co-ordination Cell 113

Chapter-6: Finance 119
Auditor's Report 119
Balance Sheet 122
Receipt & Payment Accounts 123
Income & Expenditure Account 124



OVERVIEW

The year 2015-16 has been the most fruitful year for National Institute of Solar Energy (NISE). The main highlight of the year was the visit of Honorable Prime Minister of India, Shri Narendra Modi and the French President, His Excellency, Mr. Francois Hollande, on 25th January 2016, for laying the foundation stone for International Solar Alliance (ISA) building at NISE, Gwalpahari, Gurgaon. Before the event, the newly constructed "GRIHA" rated building "Surya Bhawan" designed and constructed by NBCC, was inaugurated by Honorable Minister for Power, Coal, New and Renewable Energy and Mines, Shri Piyush Goyal on 15th May, 2015. At present the first three floors are occupied by NISE for main reception, library, Director General (NISE) office and Administration division and training and consultancy division of NISE. The top floors are engaged by the Interim Secretariat of International Solar Alliance, for their day to day activities.

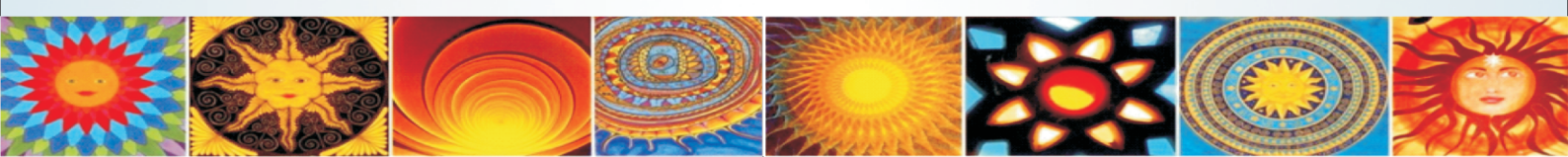
The Institute is in the process of making regular recruitment for the 41 sanctioned posts for eight identified activities as per the mandate. The major achievements during the year are in Research & Development (R&D), Resource Assessment, Testing & Certification, Training, Consultancy, Upgradation of the facilities, Hydrogen Energy and Fuel Cells, detailed as under:

Solar Resource Assessment and R&D Achievements

- In Solar Radiation Resources Assessment (SRRA) NISE has been working on analysis of data and preparation of solar maps for identification of suitable solar technologies, and also the site specific Solar Photovoltaic (SPV) module performance maps useful for different users of the country. An MoU is proposed to be signed with National Remote Sensing Centre (NRSC), Hyderabad, Indian Space Research Organization (ISRO) and NISE for taking up research on solar radiation based on satellite data. NISE is involved in the calibration of instruments as per WMO guidelines installed in the SRRA Stations in north and east India. Six Pyranometers and three Pyreheliometers from 3 SRRA Stations installed in Rajasthan were calibrated in NISE.

- In the area of Solar Thermal (ST) cooling, Vapor Absorption Machines (VAM) of different capacities 5 kW, 15 kW and 100 kW based on LiBr-water were designed and successfully demonstrated at NISE. Other R&D initiatives included the development of multi effect humidification and dehumidification distillation systems, design and simulation of solar biomass power plant for combined power, cooling and desalination to prove the concept of Poly Generation. The 1 MW Solar Thermal Power Plant based on parabolic tough collector and Linear Fresnel Reflector technologies set up in collaboration with IIT Bombay for operation and maintenance, data collection, long term performance evaluation and research and development on various components of the solar thermal power generation generated 7331 units of electricity during the year.

- In SPV, main areas of research were performance assessment and reliability of PV modules, both at NISE and other climatic zones of India. NISE has been working jointly with AIST Japan, NREL USA, PTL ASU and NCPRE IITB for qualitative and quantitative reliability studies on eight different technologies in the country. NISE research studies include important areas such as light induced degradation (LID) and Potential Induced degradation (PID) effects in PV modules. Technical Reports on "All-India Survey of PV module Degradation" and "Analysis of Performance of Thin Film Modules at NREL and NISE" and "Reliability of PV Modules" were published through these studies. During the year, modules of 2 manufacturers for full range of qualification testing and testing of 900 nos. PV modules of crystalline and thin film technology for STC and different test



conditions were completed. Fourteen nos of PV inverters and Solar pump controllers of different capacities were tested during the year. NISE carried out the performance evaluation and testing of 32 solar lanterns, 61 solar home lighting and power systems, 70 street lighting systems, six solar Task light, one solar AC, 10 charge controllers, five study lamp, three PV grid hybrid solar home systems and 37 different types and makes of SPV water pumping systems. Sixty manufacturers were provided guidance to design and develop different kinds of PV systems by way of developmental testing. Installation of a 500 kWp SPV power plant based on five different technologies for performance evaluation in Indian conditions was taken up during the year.were completed. 14 Nos of PV inverters and Solar pump controllers of different capacities were tested during the year. NISE carried out the performance evaluation and testing of 32 solar lanterns, 61 solar home lighting and power systems, 70 street lighting systems, 6 solar Task light, 1 solar AC, 10 charge controllers, 5 study lamp, 3 PV grid hybrid solar home systems and 37 different types and makes of SPV water pumping systems. 60 No. of manufacturers were provided guidance to design and develop different kind of PV systems by way of developmental testing. Installation of a 500 kWp SPV power plant based on 5 different technologies for performance evaluation in Indian conditions was taken up during the year.

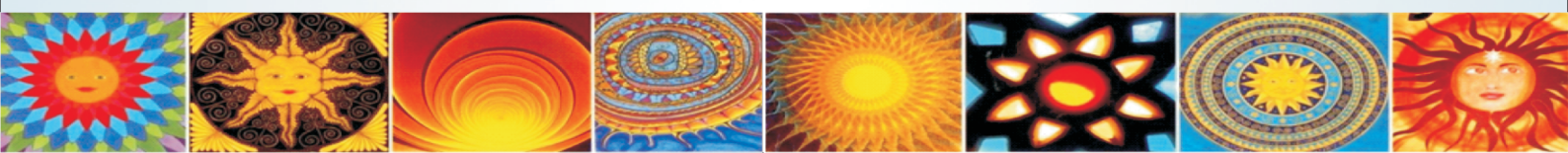
- The studies on Photovoltaic modules systems and power plants have resulted in 15 publications in international Journals, 20 presentations in EUPVSEC and IEEEPVSC conferences, and presentations in national seminars, workshops and conferences in the field of PV module performance and reliability. Few of these publications also received awards for their value addition in the area of PV Reliability research. A book entitled "*Advances in Solar Energy*" (Science and Engineering), Volume-1 was published during the year. The Book provides the important highlights of research and developments in the area of solar energy including photovoltaics.

Testing and Certification:

Testing, Certification and Standardization of PV systems and components continue to be the main revenue generation activity of NISE. During the year 2015-16, number of SPV systems for water pumping, lighting and other applications are tested and certified at NISE. The components tested include, PV modules, Inverters and batteries and were the main revenue earners. Full range of qualification testing of SPV modules of 2 manufacturers were completed and another 900 nos. PV modules of crystalline and thin film technology were tested for STC and different test conditions. An amount of about Rs. 1.5 Crores were earned through testing and certification activity.

Skill Development

The training and skill development is another important activity of NISE. Training is offered in different areas of solar energy for different target groups. The flagship programme in field of skill development is the "SuryaMitra" (SM), skilling of lower grade technicians for installation, operation, maintenance and repair of SPV systems. NISE has co-ordinated the Surya Mitra Programme being conducted with the funding and support of MNRE in different institutions in the country including NISE. Under the Programme NISE organised two training programmes on its campus and trained 52 candidates during the year. During the year 2015-16, about 100 institutions were identified and accredited by NISE for conducting SuryaMitra. The selection of these institutions is done based on their past experience, lab facilities in electrical and PV, expertise, and experience in the area of solar energy. NISE also organized training programmes for Senior Defense Officials, Charted Engineers, State Nodal Agencies (SNAs) officials, and other users in the country. Special training programmes were also organized for users of Northern East regions and other states. NISE has conducted training programme for design engineers on



"PV system Design" using 6 different software packages, viz, PV syst., PVSOL, TSOL, SAM, RET Screen and Archelios Pro softwares. Other areas of training included solar water pump system, solar water heating, and energy access. Apart from this, NISE has also organized training programmes for the Training of Trainer (ToT) of SM. NISE also launched a Mobile Application for SM for an easy access of the skilled personnel, on Pan India Basis. NISE also organize training programmes for international participants on be-half of Ministry of External Affairs (MEA). International training programmes are organized under ITEC- Indian Technical & Economic Cooperation programme, African countries and SAARC countries. Training has been another major source of revenue generation for NISE.

Consultancy:

Keeping the expertise, experience and facilities available at NISE, the Institute also launched a new activity on "Consultancy" for different users. The key offerings under this activity are preparation & wetting of Feasibility Reports (FRs) and Detailed Project Reports (DPRs) for PV power plants. About 31 projects were taken up during the period for Defense Ministry. NISE is also offering Quality Verification Services for inspection and proper installation and commissioning of Photovoltaic power plants in the country. NISE has initiated steps for establishing a Technology Business Incubation Centre in its campus to help the young entrepreneurs and other users, whoever has innovative ideas/concepts in the area of solar energy. This is expected to start functioning during the next financial year.

Hydrogen and Fuel Cells:

The Hydrogen and Fuel cells project sanctioned by MNRE showed significant progress. The project has been completed and 120 kWp PV power plant is made operational. Production, storage and dispensing of H_2 is regularly carried out. For establishing the fuel cell testing laboratory the required components have been procured. Installation of test lab was taken up and commissioning is likely to be completed during the next year.

New Upcoming Facilities at NISE:

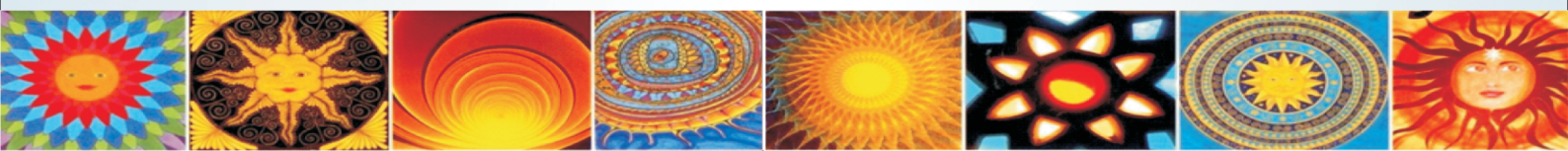
During this year NISE has added few new facilities for PV modules, apart from upgrading the existing facilities. Electro-luminous and IR imaging for PV module is the latest technique for detection of defects in modules. A design simulation lab with six different software packages for system design and training of users is established at NISE. NISE is proposing to acquire two new material characterization systems XRD and SEM for structural characteristics of solar cell materials, for in-house project use and helping researchers in R&D projects.

External Audit:

The external financial and accounts audit is conducted by M/s …… A copy of the Auditors report is also enclosed.

Lastly the above developments during the year set the vision and future direction for the NISE. The upgradation of testing, certification, training and consultancy activities initiated guarantees regular income for the institute and ensures the sustainability and self-reliance of NISE in the coming years.

S. K. Singh
Director General



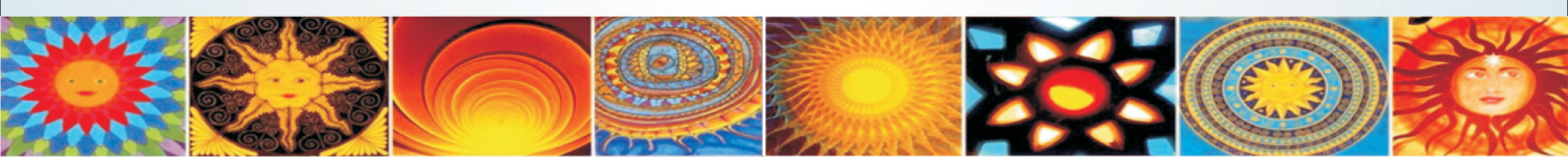
Administration

National Institute of Solar Energy has been set up as an autonomous Institute by conversion of the erstwhile Solar Energy Centre, an attached office under Ministry of New & Renewable Energy. Forty one regular posts have been sanctioned for the National Institute of Solar Energy. The Institute has framed Recruitment Rules for the following sanctioned 41 regular scientific, technical and administrative posts. The Rules were approved by Governing Council in its 3rd meeting held on 6th April, 2015. The posts were advertised on all India basis in Employment News and on Ministry and Institute websites. The 10,000 and odd applications received were registered and displayed on the Institute website. The applications were screened by different Committees constituted for the purpose. An agency has been identified to conduct the examination for different categories of posts.

Sl. No.	Name of the post	PB+GP	No. of posts		
			Technical	Admin	Total
1.	Director General	PB-4 +10000	1	0	1
2.	Deputy Director General	PB-4 +8900	3	0	3
3.	Director	PB-3+7600	2	1	3
4.	Deputy Director	PB-3+6600	6	2	8
5.	Assistant Director	PB-3+5400	7	2	9
6.	Administrative Officer	PB-3+6600	0	1	1
7.	Office Secretary	PB-2+5400	0	1	1
8.	Office Secretary-I	PB-2+4800	0	3	3
9.	Executive Officer	PB-2+4800	4	0	4
10.	Executive Assistant –I	PB-2+4600	8	0	8
	Total		**31**	**10**	**41**

In the meantime, the Institute has been functioning with the help of five officers from Ministry who are assisted by Senior Consultants and Consultants to attend to scientific and administrative assignments to run the Institute. The Laboratories of the Institute are run with the assistance from Project Fellows. Different groups formed at the Institute have been assigned different activities to focus on all important functions. The support staff has been engaged through an outsourced manpower agency. During the year, the Institute has upgraded different laboratories and set up new laboratories to ensure meeting the ever increasing demand for testing and certification

The Institute Building "Surya Bhawan" constructed by National Building Construction Corporation was inaugurated by Hon'ble Minister for Power, Coal, and New & Renewable Energy on 15th May, 2015. The building locates Director General's Office and Administrative Wing and two floors are assigned to International Solar Alliance Interim Secretariat.





Shri Piyush Goyal, Hon'ble Minister for New and Renewable Energy (IC) inaugurated the Surya Bhawan based on Solar Passive Architecture on 14th May, 2015. Shri Upendra Tripathy, Secretary MNRE is seen with other officials

The Institute has developed infrastructure facilities for undertaking National and International Training Programmes and arranging Suryamitra Skill Development Programmes. The Institute also continued with the process of development of appropriate infrastructure for additional energy requirements, adopting safety measures for electrical installations, internal road network, etc.

Prime Minister Shri Narendra Modi and French President Mr. François Hollande laid foundation stone of International Solar Alliance (ISA) Headquarters and inaugurated the interim Secretariat of ISA at National Institute of Solar Energy (NISE) in Gurgaon on 25th January 2016. The Interim Secretariat of ISA was also inaugurated in the Surya Bhawan on its third and four floors at the Institute Campus by them.



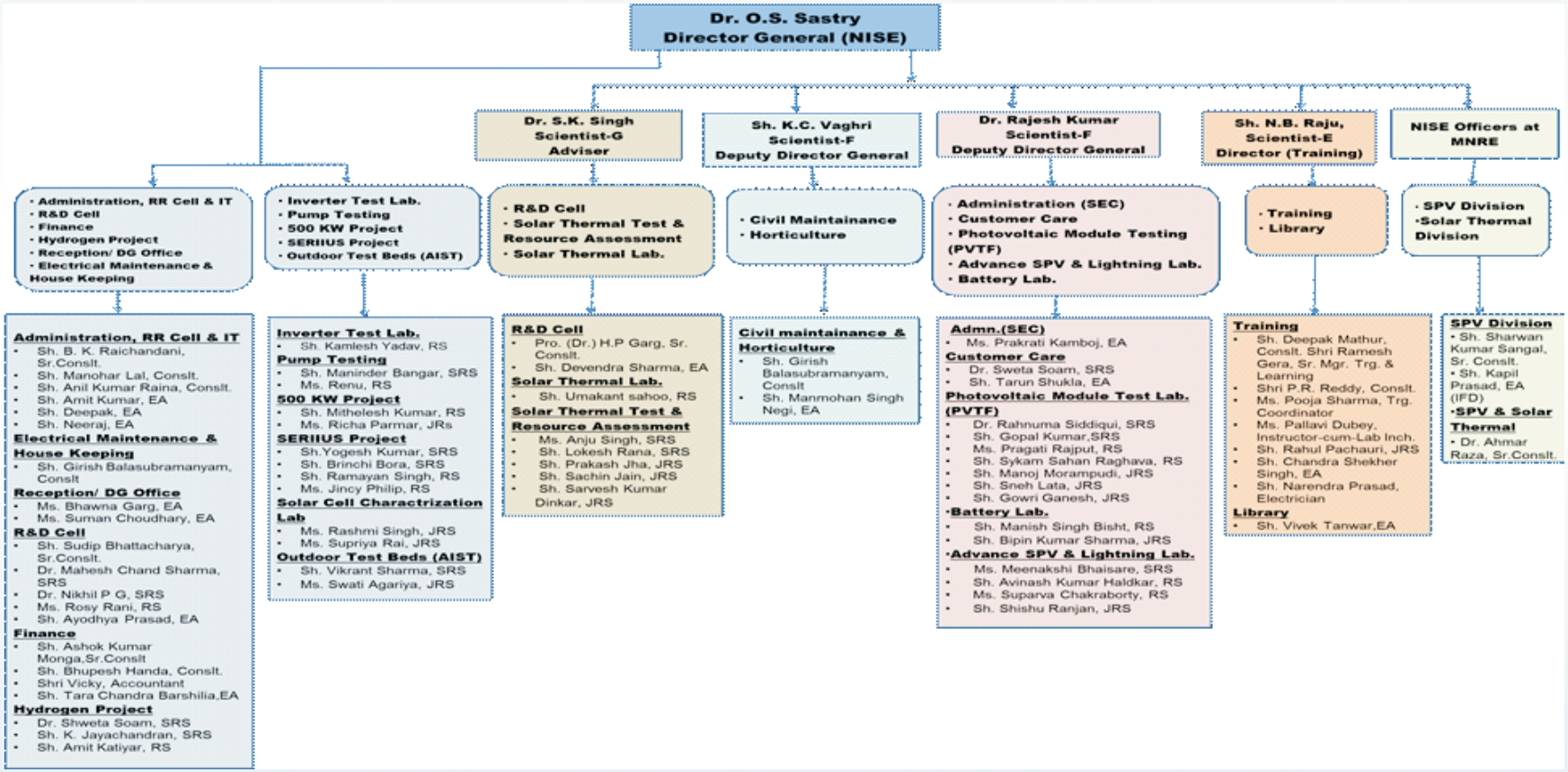


Foundation stone laying ceremony of International Solar Alliance (ISA) Headquarters cum Inauguration of Interim Secretariat of ISA and at NISE Gurgaon on 25 January 2016 by Indian Prime Minister Shri Narendra Modi and French President Mr. Francois Hollande

The organogram of the distribution of work amongst different Divisions and Laboratories at the National Institute of Solar Energy is given as under:

NISE
National Institute of Solar Energy

NATIONAL INSTITUTE OF SOLAR ENERGY



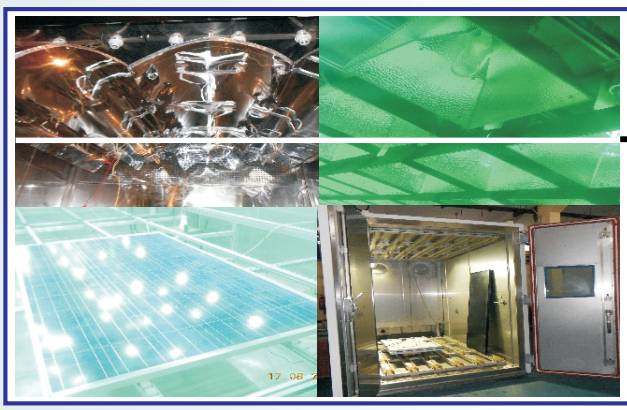
Chapter-1

SOLAR PHOTOVOLTAIC DIVISION

1.1 Photovoltaic Test Facility



QUALITY POLICY National Institute of Solar Energy is committed to provide world class testing services to its customers by maintaining good professional practices and quality of testing in the field of photovoltaic measurements, meeting the requirement of international standards for Qualification testing of photovoltaic modules and systems. This is being achieved by maintaining state of the art infrastructure, testing methods of international level competent and well trained employees and continual improvement of the effectiveness of the Quality Management System as per International Standards ISO/IEC 17025:2005.



17025:2005

PVTF

NABL Accredited Lab

Certificate No.: T-1848

INTRODUCTION

Photovoltaic module testing facility at National Institute of Solar Energy is NABL (National Accreditation Board for Testing & Calibration Laboratories) accredited laboratory as per standard IS 17025: 2005. PVTF has the best workforce in delivering the work and always strives towards quality improvement. PVTF laboratory is well-equipped and has well-trained, experienced and skilled personnel to conduct the tests as per the National (BIS) and International Standards (IEC/UL/JIS/ASTM/VDE). PVTF offers a wide range of services such as Quantitative and Qualitative analysis of PV modules by testing them according to the following Standards to the customers:

- IEC 61215 :

  Crystalline silicon terrestrial photovoltaic (PV) modules Design Qualification ***and type Approval***

- IEC 61646 :

  Thin–film terrestrial photovoltaic (PV) modules Design Qualification ***and type Approval***

- IEC 61730: (part I & II)

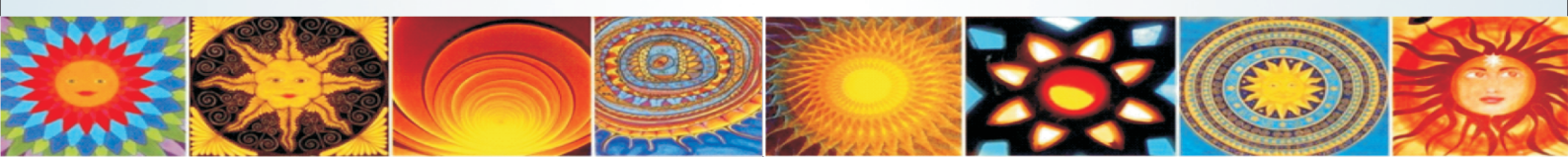
  Photovoltaic module safety qualification

Additional Services

- Quality Benchmarking Testing of PV modules.
- Extended Impact Tests.
- Tests shall be performed as per user specific standards.
- Root-cause analysis
- Performance measurements
- Infrared Image thermography
- Analysis of Potential Induced Degradation (PID).
- Calibrated modules for manufacturers and quality control.
- The following PV technologies are tested at NISE (PVTF Lab).

1. Crystalline solar module
   a. Mono crystalline
   b. Multi crystalline

2 Thin Film
a. Amorphous
b. CdTe and c. CIGS



Activities

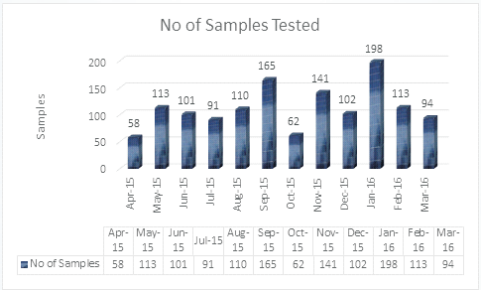
- Around **1350** PV modules were tested during 2015-16 for routine I-V Characteristics.
- Performance testing can be done for Design, Quality and Safety Criteria for different manufacturers.
- Following Documents have been revised according to the latest edition.
  - Quality Manual
  - Technical Procedure
  - Executive Procedure
  - Operating Procedure.
- PVTF at NISE is in a process of getting recognized as Testing Facility for Photovoltaic Systems by Bureau of Indian Standards.
- Procurement of the following equipments is in process
  - Salt Spray Chamber
  - Two DC Power Supplies.
  - Sun simulator with Built-in Chamber (under tender Process).
  - Sun simulator with spectral response (under tender Process).
- Designed a new PVTF Brochure and updated the website content.
- Participated in Indo- African Summit and exhibited a Poster on Lab.
- Updated the web content of PVTF Division.
- Jointly Visited PV modules Testing Labs of TUV and UL Bangalore.
- Carried out "All India Survey of Photovoltaic modules degradation: 2015-16" in association with IIT, Bombay.
- Joint Collaboration with ISE, Germany for improving the Testing service Quality.

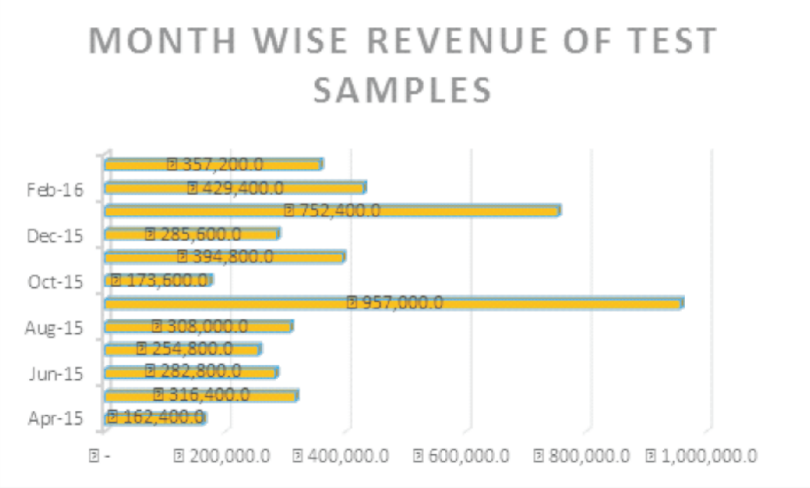
New Upcoming Initiatives:

- Salt Mist Corrosion Testing according to IEC 61701 (ed.1 & ed.2).
- Light Induced Degradation.

Revenue Generated by PVTF during 2015-16:

- Income earned on routine Performance Testing (STC) is approximately ₹. 41,79,400 (Forty one Lakhs Seventy Nine Thousand and Four Hundred).
- Revenue generated on IEC testing is approximately ₹ 20,32,580 (Twenty Lakhs Thirty two Thousand Five Hundred and Eighty).
- Number of Samples tested during the year 2015-16 are 1348.





Training Programs and Conferences Organized/Attended:

- Four Scientists of NISE attended Training Program on "Laboratory Quality Management System and internal audit as per ISO 17025 :2005" at Indian Institute of Quality Management (IIQM), Jaipur, India from 21st to 24th July, 2015.

- Four Scientists of NISE attended a three-day Training on "measurement of Uncertainty", organized by Centre for Electronic Test Engineering (CETE), Noida, from 2nd March to 4th March, 2016, for improvement of the measurement skills

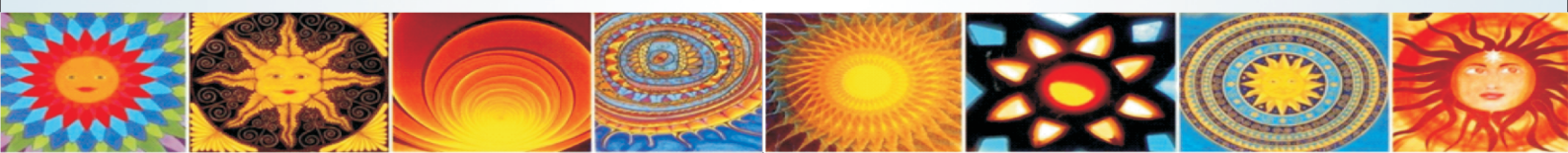
- Organised a Three day workshop on the Calibration of Secondary Cells chaired by Dr. Jochen Hohl-Ebinger, Fraunhofer ISE held at NISE.

- Organised a workshop on Measurement of Uncertainty for Sun-Simulators for expert consultation with Fraunhofer Group Mr. Ulli Kraling, and Mr. Daniel Philip at PVTF Lab

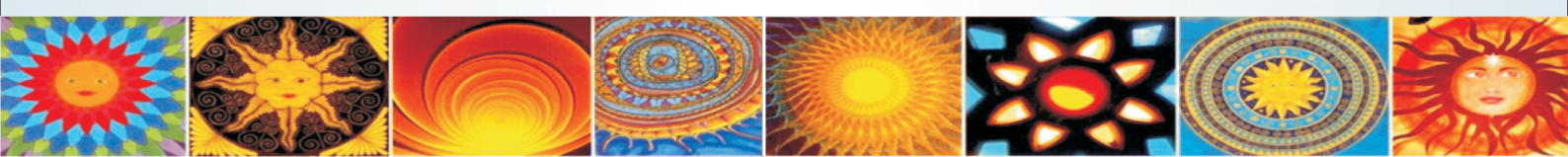
- Participated in Training on **PVSyst** and **PVSOL.**

State wise Manufacturer Details of Samples Tested

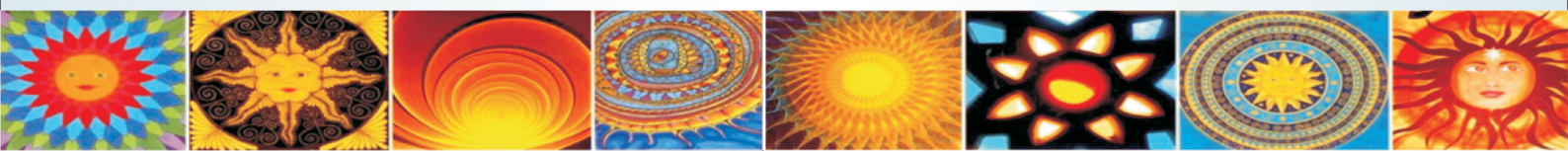
S.NO	STATE/UNION TERRITORY	MANUFACTURER	ADDRESS
1	Andhra Pradesh	Shaan Solar	#900 South Road No. 8 Sricity SEZ, Sathyavedu Mandal Chittoor Dist, Andhra Pradesh – 517 588 Phone: +91 8576 320902 Fax: +91 8576 308979
2	Bihar	QMAX unit of Indus Multi Service Pvt Ltd	Basant Bihar Lane, opp. Tapashaya Complex, Boring Road, Patna
3	Chattisgarh	Green World Solar Wares Tech & Energy Pvt Ltd	29, Vidhayak Colony Behind 36 City Mall
		Meenakshi Power Solution	Azad Ward, Ring Road, Ambikapur Surguja
		Lanco Solar Pvt.Ltd.	Mehroom khurd & Chawardhal
4	Delhi/New Delhi	Claro Energy Pvt.Ltd.	91, DSIDC Sheds, 2nd floor Okhla Industrial Area Schme-1
		Radical Solar Pvt Ltd.	B-20/2, Okhla Industrial Area, Phase-2
		The Energy and Resources Institute	Darbari Seth Block, 1HC Complex Lodhi



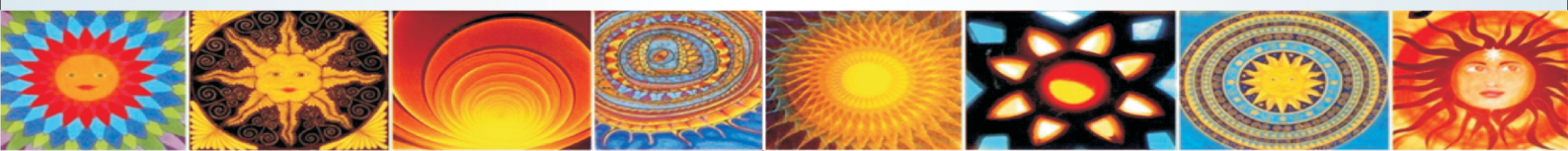
		Radical Solar Pvt.Ltd.	B-20/2 Okhla Industrail Area Phase-2
		Alpex Exports Pvt.Ltd.	81/2 Sri Aurbindo Marg Adhchini
		Gautam Solar Pvt.Ltd.	F-33, Okhla Industrial Area, Phase-1
		Innova Solar Systems Ltd	212 Vikas Building Laxmi Nagar District Center
5	Gujarat	Navitas Green Solutions Pvt.Ltd.	B-20/3, Road No-13/14, Hojiwala Industrial Estate Sachin Palsana highway
		Vipson Solar Energy Pvt.Ltd.	FF-108, Dev Shikhar Commercial near ganesh circle
		Solex Energy Pvt Ltd.	Plot No-131/A, Phase-I, Nr.Krimy, G.I.D.C, Vittal Udyog Nagar
		Australian Premium Solar India P.Ltd.	Plot No.143 Road No.4A, GIDC Kathwada
		Sonali Energies Pvt.Ltd.	C-208, Belgwne Chamber Ring Road
		Elecssol Energy Systems	C-206, Devaditya Arcade opp.Silver Square Complex Nr.Baghban Party Plot, Thaltaj-Shaial Road, Thaltej
		Goldi Green Technologies Pvt.Ltd.	Block no.149, Plot No. J&K/1, B/S IOC Detrol



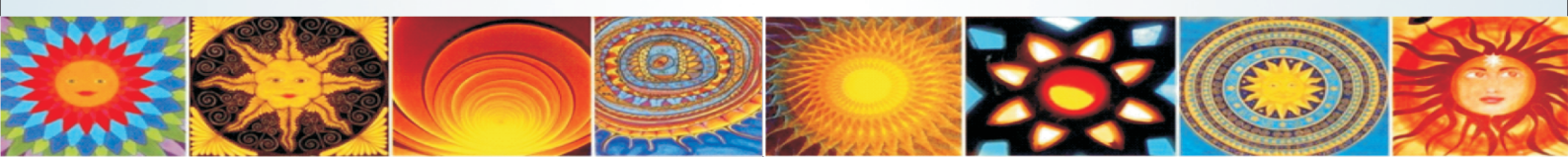
			Pump Hpodra, N.H-8
		Sun 2 Earth Solar	No-1,Part-1, Bhajiwala Industrail Estate Sardar Smruti Bhavan,
		Amrut Energy Enterprise	Plot No.303 Shivamvally Nr.Shriji Residency B/H Silver Star Mall, Chanlowiya
		Uratom Solar India Pvt Ltd.	"Yugadhar"-10 Yogi Nagar
6	Haryana	Punchline Energy Pvt.Ltd.	328, Phase-II, Udyog Vihar
		Rhine Solar Limited	Plot No.417E, PIP Phase-III Kundli Ind Estate
		Neosol Technologies Pvt.Ltd.	Plot No.173,Sector-6,IMT Manesar
		INSO Solar Pvt.Ltd.	Plot No.1537, Sector-53,HSIDC,Indutrial Estate Kundli
		Mansa Solar Energy	98-99, Jarnally Kothi Dyal Singh Collage Road
		Cambridge Energy Resources P.Ltd.	1166 & 1167, 11th Floor Tower B-1 Spaze-I Tech Park, Sec-49, Sohna Road
7	Karnataka	Kotak Urja Pvt.Ltd.	378, 10th Cross, 4th Phase Peenya Industrial Area
		Auro Power Systems Pvt.Ltd.	33, Dena Bank Colony, Off Bellary Main Road ND Cross Ganga



			nagar
8	Madya Pradesh	Pragat Akshay Urja Ltd.	Plot No.41, Sector-3, Pitampura Industrail Area
9	Rajasthan	Illusions 4 Real	D104/2 Meera Marg,Bani Park
10	Tamilnadu	Borg Energy	No.9c & 9d, 9th floor, P.M Towers,37 greams Road
		Ammini Solar Pvt.Ltd.	Plot No.33-37, Kinfra Small Industries Park St.Xavier's Collage
11	Telanagana	Neeta Innovative Technology Manufacturers	Shed No.27, Road No-15 IDA Mallopur, Nacharam
		Sun Energy Systemes India Pvt.Ltd.	# 133/1/B Phase-II, IDA Cherlapally
		Andromeda Energy Technologies P.Ltd.	No.B-72,Phase-1, I.W.A,Jeedimetla
		Surana ventures ltd	5th floor surana tower s.p road , secunderabad, telangana
		Bhargava Solar Engineers	#58-2-181 near Ntrcircle Pantaralvua Road Patamata
		Photon Energy System Ltd.	#8-2-686/DB/12 Mount View enclave Road No.12 Banjara Hills
12	Uttar Pradesh	Jakson Engineers Ltd	A-43, Phase-II Opp. NSEZ
		Akshay Jyoti Energies Pvt.Ltd	11/48 Ghathras Road



		Ritika System Pvt Ltd	C-22/18, Sector-57
		Easy Photovoltech Pvt. Ltd.	Solar Coottage, Meerut Road
		Integrated Batteries India Pvt Ltd.	D-127 sector-63
		Maharishi Solar Technology (P) Ltd.	C-146 Hosiery Complex, Phase-11, Gautam Budh Nagar
		Central Electronics Ltd.	4-Industrial Area Sahibabad
		Tulsi Pumps & Power Pvt.Ltd.	Malda bridge Crossing (Ram Machinary)
13	West Bengal	Vikram Solar	Tobacco house, 1 old court corner
		Synergy Electric Pvt.Ltd.	Trishul Ground Floor, 35 Rowland Road

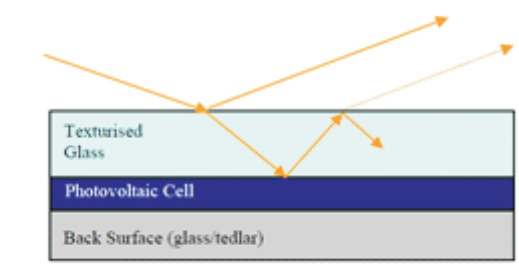


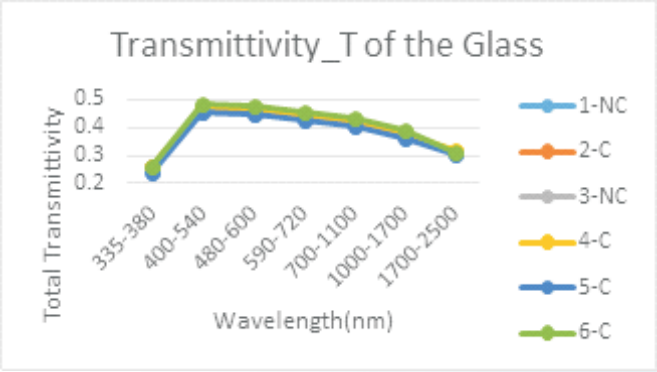
Research & Development:

- **Study of Selective Coatings applied on Glass of PV Modules**.

Solar PV modules with various kinds of coatings on the front glass surfaces are being marketed by different manufacturers. Antireflective coating (ARC) is the most common type used by many manufacturers. There are other special kinds of coatings which enable the self-cleaning mechanism on the glass without using water and are maintenance free as claimed by the suppliers.

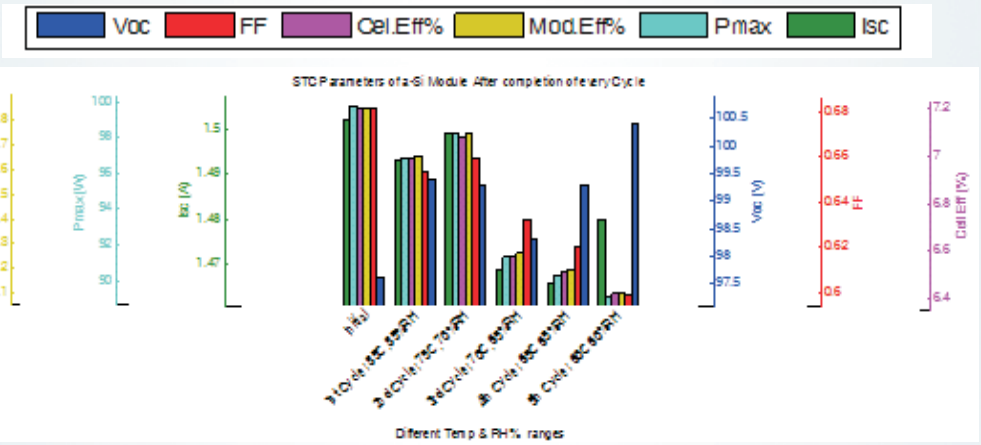
The coatings offer low-friction surface to the dust and stops it from accumulation on the glass surface. These coatings also do not allow the bird feaces to stick to the glass. Its hydrophobic properties repels water from the panel increasing the amount of light transmitted during wet weather. A study was conducted to evaluate the performance of such coatings at NISE on different PV modules.





Effect of dark soaking of different PV Technology modules under Damp heat conditions.

Description: The power output of PV modules in general depends on the meteorological parameters like irradiance, temperature and humidity applied on each module. The same effects were simulated by using environmental chamber and power supplies. The dark forward biasing has been done in conjunction with the various levels of temperatures and humidity (Damp heat). After predefined soaking period of 200 hours the power measurements were performed periodically. The quantitative analysis on the results are shown in the graph. The degradation pattern of the different technologies were studied.



Publications:

The following papers were communicated for publication in different Scientific Journals and National/ International Conferences

- Paper entitled as "A Review on Different types of PV testing and their Optimization", Gayatri Nanda, Sarat Chandra Swain, Rajesh Kumar, Ritesh Das, Gopal Jha, Rahnuma Siddiqui

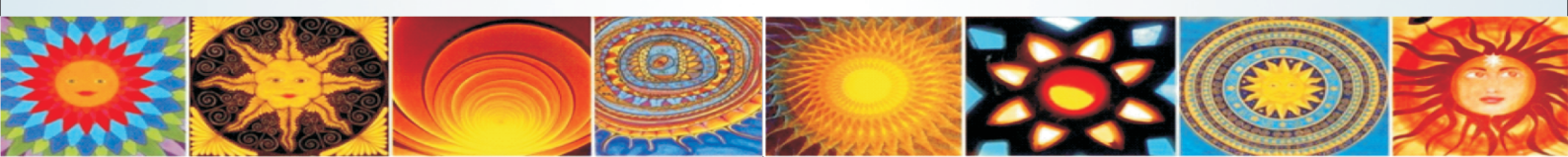
- "Comparison of Different Technologies for Solar PV outdoor performance using indoor Accelerated Aging Tests for Long Term Reliability", Rahnuma Siddiqui, Rajesh Kumar, Gopal Kumar Jha, Ganesh Gowri, Manoj Morampudi, Pragati Rajput, Sneh Lata, Swati Agariya, Bharat Dubey, Gayatri Nanda, Sykam Sahan Raghava, Energy, Vol 107, pp. 550-561, 2016

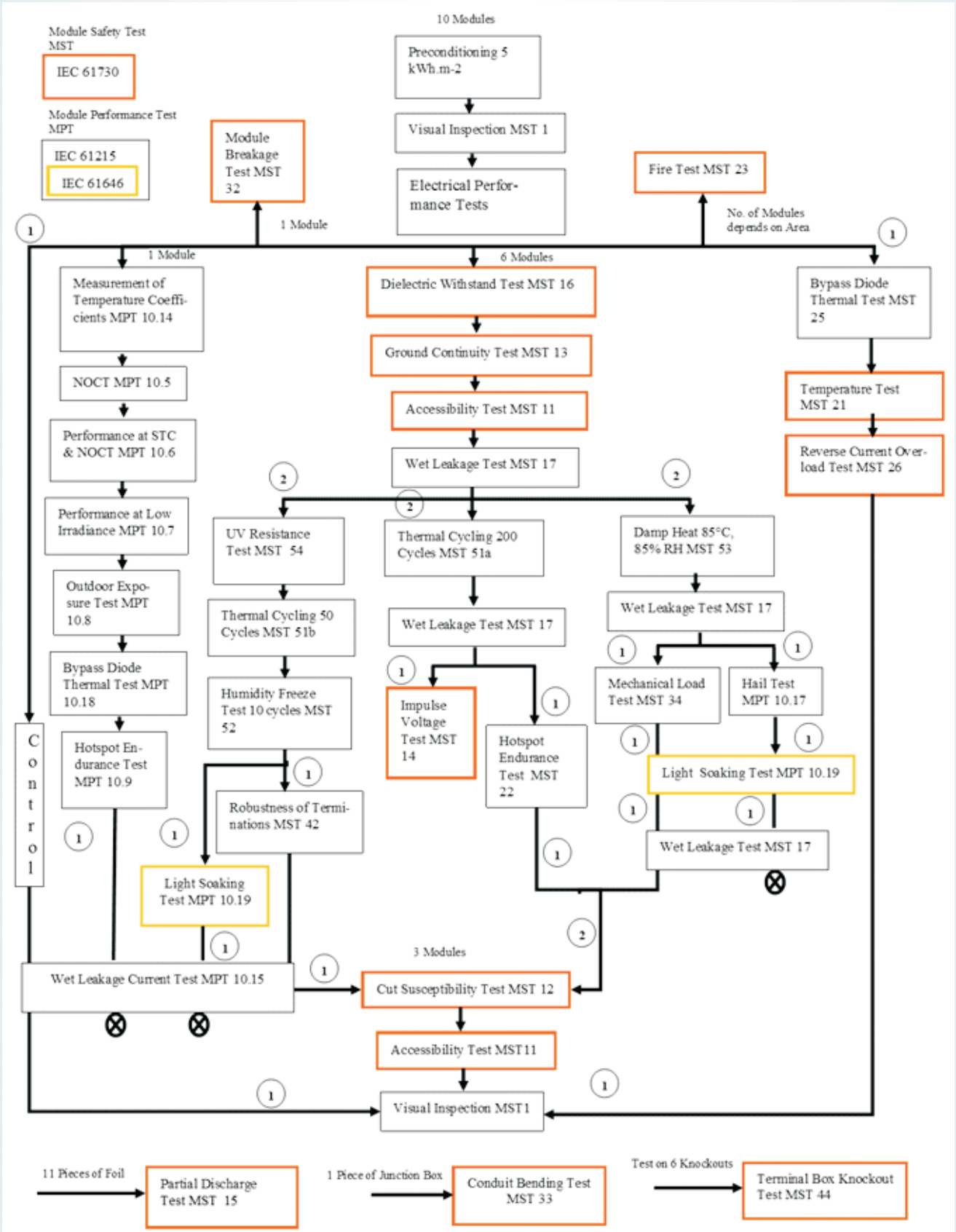
- Paper entitled as " Selection Criteria of PV Technology based on specific site", Gopal Kumar Jha, Rajesh Kumar, Rahnuma Siddiqui, Sahan Raghava, Pragati Rajput, Manoj Morampudi, Sneh Lata, Ganesh Gowri, EUPSEC 2016 (operation performance, reliability and sustainability of Photovoltaic (PV cells and Modules). [Under communication]

- Paper entitled as " Performance comparison of PV modules based on temperature coefficient in indoor and outdoor conditions as per IEC 61853-1", Manoj Morampudi, Brinchi Bora, Gopal Kumar Jha, Rajesh kumar, Rahnuma Siddiqui, Sneh Lata, Ganesh Gowri, Pragati Rajput, Sahan Raghava, Bharat Dubey, Mayank, Gayatri, EUPVSEC 2016 operation performance, reliability and sustainability of Photovoltaic (PV cells and Modules).[under communication].

- Paper Entitled as " Effect of temperature on insulation resistance of different PV technologies", Ganesh Gowri, Manoj Morampudi, Sneh Lata, Sahan Raghava, Pragati Rajput, Rajesh Kumar, Gopal Kr Jha, Rahnuma Siddqui, EUPVSEC 2016 (operation performance, reliability and sustainability of Photovoltaic (PV cells and Modules).[under communication]

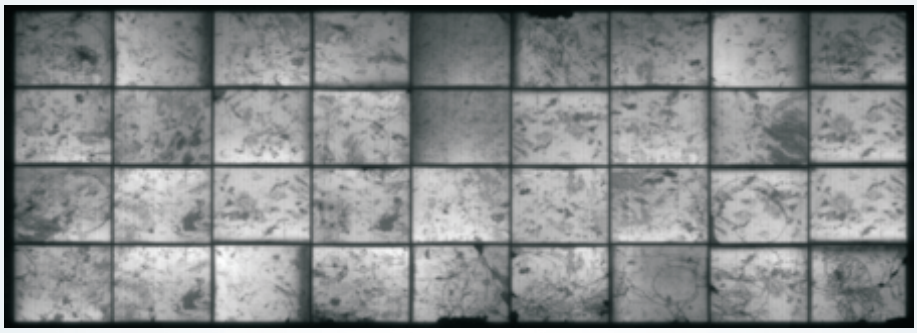
CONSOLIDATED FLOW CHART OF IEC 61215, IEC 61646 and IEC 61730: NISE prepared the following flow Chart combining the two specific standards IEC 61215, IEC 61646 and IEC 61730




Module Safety Test MST
IEC 61730
Module Performance Test MPT
IEC 61215
IEC 61646
Module Breakage Test MST 32
10 Modules
Preconditioning 5 kWh.m-2
Visual Inspection MST 1
Electrical Performance Tests
Fire Test MST 23
No. of Modules depends on Area
1 Module
1 Module
6 Modules
Measurement of Temperature Coefficients MPT 10.14
NOCT MPT 10.5
Performance at STC & NOCT MPT 10.6
Performance at Low Irradiance MPT 10.7
Outdoor Exposure Test MPT 10.8
Bypass Diode Thermal Test MPT 10.18
Hotspot Endurance Test MPT 10.9
Control
Dielectric Withstand Test MST 16
Ground Continuity Test MST 13
Accessibility Test MST 11
Wet Leakage Test MST 17
Bypass Diode Thermal Test MST 25
Temperature Test MST 21
Reverse Current Overload Test MST 26
UV Resistance Test MST 54
Thermal Cycling 50 Cycles MST 51b
Humidity Freeze Test 10 cycles MST 52
Robustness of Terminations MST 42
Thermal Cycling 200 Cycles MST 51a
Wet Leakage Test MST 17
Impulse Voltage Test MST 14
Hotspot Endurance Test MST 22
Damp Heat 85°C, 85% RH MST 53
Wet Leakage Test MST 17
Mechanical Load Test MST 34
Hail Test MPT 10.17
Light Soaking Test MPT 10.19
Wet Leakage Test MST 17
Light Soaking Test MPT 10.19
Wet Leakage Current Test MPT 10.15
3 Modules
Cut Susceptibility Test MST 12
Accessibility Test MST11
Visual Inspection MST1
11 Pieces of Foil
Partial Discharge Test MST 15
1 Piece of Junction Box
Conduit Bending Test MST 33
Test on 6 Knockouts
Terminal Box Knockout Test MST 44

Electroluminescence & Thermal Image Analysis:

- Defect detection in Photovoltaic Modules using Electroluminescence Imaging
- The significance of thermal imaging is to trace out the possible defects such as interconnects, broken and shorted cells which generally occurs during manufacturing process/ testing.



OPERATING PROCEDURES & TEST FACILITIES:

The following safety Tests as per the Standard IEC 61730 are conducted at NISE

Accessibility Test:

The purpose of this test is to check user accessible live parts like junction box which can pose the problem while they come in contact with the living beings and to determine if uninsulated electrical connections represent a shock hazard to personnel

Ground Continuity Test:

To demonstrate that there is a conductive path between all exposed conductive surfaces of the module, so that the exposed conductive surfaces can be adequately grounded in a PV system. This test is required only if the module has exposed conductive parts such as a metal frame or a metallic junction box.

Dielectric Withstand Test:

To determine whether or not the module is sufficiently well insulated between current carrying parts and the frame or the outside world.

The test shall be made on modules at ambient temperature of the surrounding atmosphere and in a relative humidity not exceeding 75 %.

This test is identical with insulation test from IEC 61215/IEC 61646 with test levels depending on the application class and the maximum system voltage.

The maximum test voltage shall be equal to 2 000 V plus four times the maximum system voltage for application-class A and equal to 1 000 V plus two times the maximum system voltage for application-class B.

Wet Leakage Current Test:

To evaluate the insulation of the module under wet operating conditions and verify that moisture from rain, fog, dew, or melted snow does not enter the active parts of the module circuitry, where it might cause corrosion, a ground fault or a safety hazard

Impulse Voltage Test:

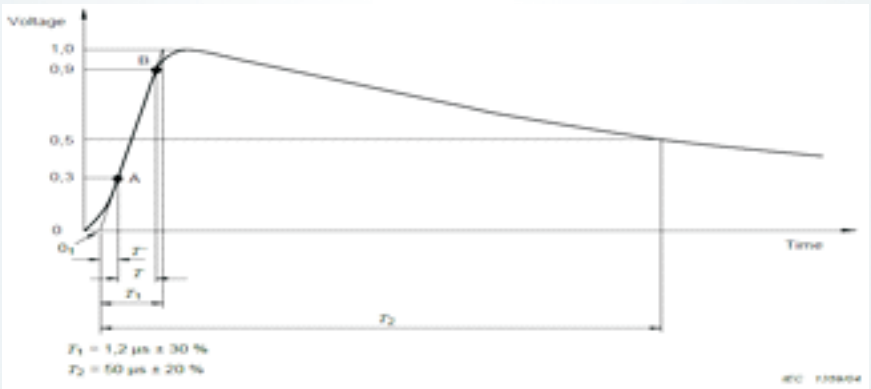
To test Solid insulation of the Solar PV module to withstand over-voltages caused by lightning surges and switching transients of Low- Voltage Equipment.

The Applied Voltage Ranges (intermediate voltages may also be covered) are as mentioned below:

Table : Test Voltages

System voltage	Impulse voltage levels	
	Application Class A	**Application Class B**
100	1500	800
150	2500	1500
300	4000	2500
600	6000	4000
1000	8000	6000

Waveshape:



Reverse Load Current Test:

Modules contain electrically conductive material, contained in an insulating system. Under reverse current fault conditions, the tabbing and cells of the module are forced to dissipate energy as heat, prior to circuit interruption by an over-current protector installed in the system. This test is intended to determine the acceptability of the risk of ignition or fire from this condition.

Cut Susceptibility:

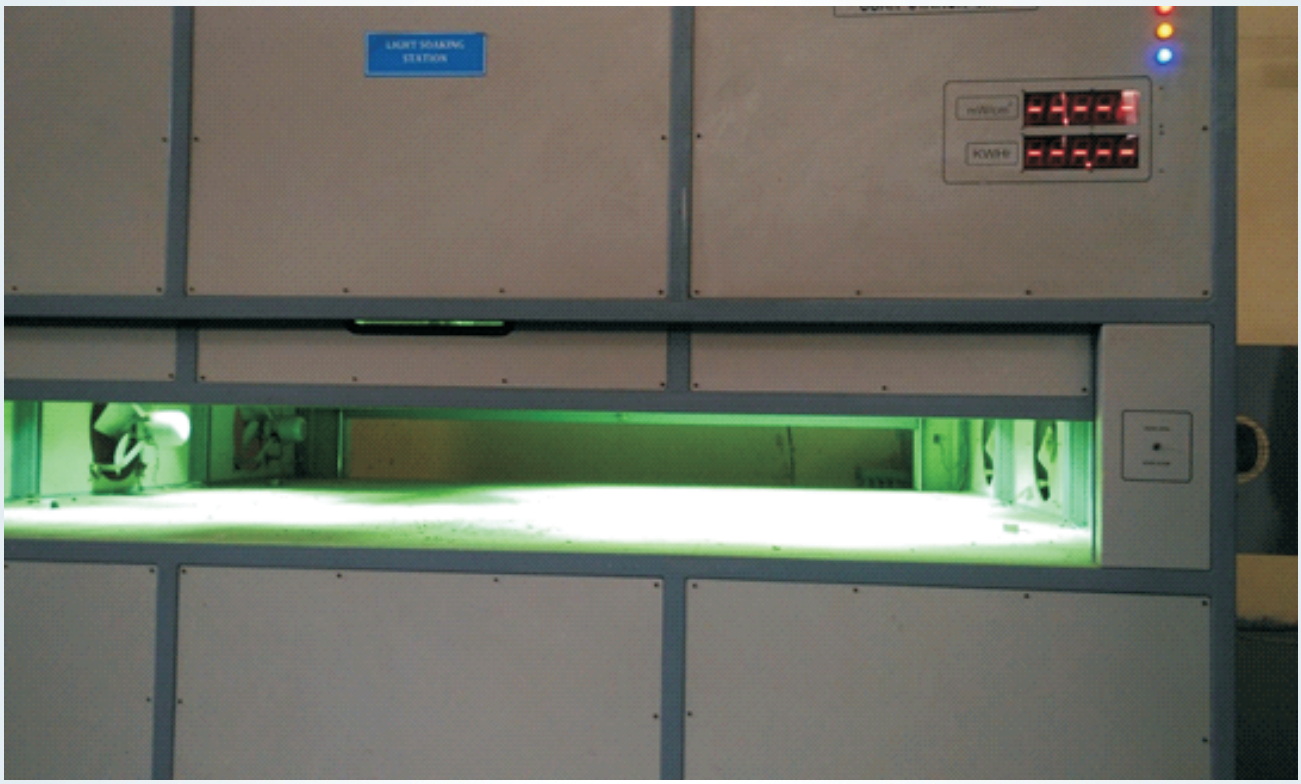
To determine whether any front and rear surfaces of the module made of polymeric materials are capable of withstanding routine handling during installation and maintenance without Exposing personnel to the danger of electric shock.

Temperature Test:

This temperature test is designed to determine the maximum reference temperatures for various components and materials used to construct the module, in order to establish the suitability of their use.

Light Soaking Station:

To compensate the structural defects in the thin-film Technologies modules by means of natural sunlight or simulated solar irradiation and to stabilize electrical characteristics



1. 2 POWER ELECTRONICS LAB

1. Introduction: Power Electronics Lab of National Institute of Solar Energy (NISE) focuses on research and development, testing and performance evaluation and certification of Solar Photovoltaic Power convertors. This group has capabilities and expertise in measurements, characterization, reliability, engineering, scientific computing, and theory to support research in power electronics, balance of system and development (R&D) for photovoltaic (PV) systems. This group is closely working with renowned national institutes to develop world class facility at NISE for the testing and performance evaluation of solar Inverters for Indian conditions

1.1 Power Electronics lab:

NISE has established facilities for testing and evaluation of Solar Inverters/ power conditioning Units (PCU) of capacity up to 50 KVA. All types of PCUs, hybrid, standalone, Grid-tied inverters (GI) and pump controllers can be tested. NISE's power electronics lab has four Solar Array Simulators (15 KVA X 4), Actual RLC load 60 KVA, Electronic load simulators (4.5 KVA x 3), programmable AC source (6 KVA), Four Channel and Six Channel Power Analyzers, Digital Oscilloscopes, Bench Top Dual Display Multi-meters etc. The test reports contain all the useful parameters measured at NISE as per National and International standards. The report also includes claims made by manufacturer and observations made during the evaluation of the sample

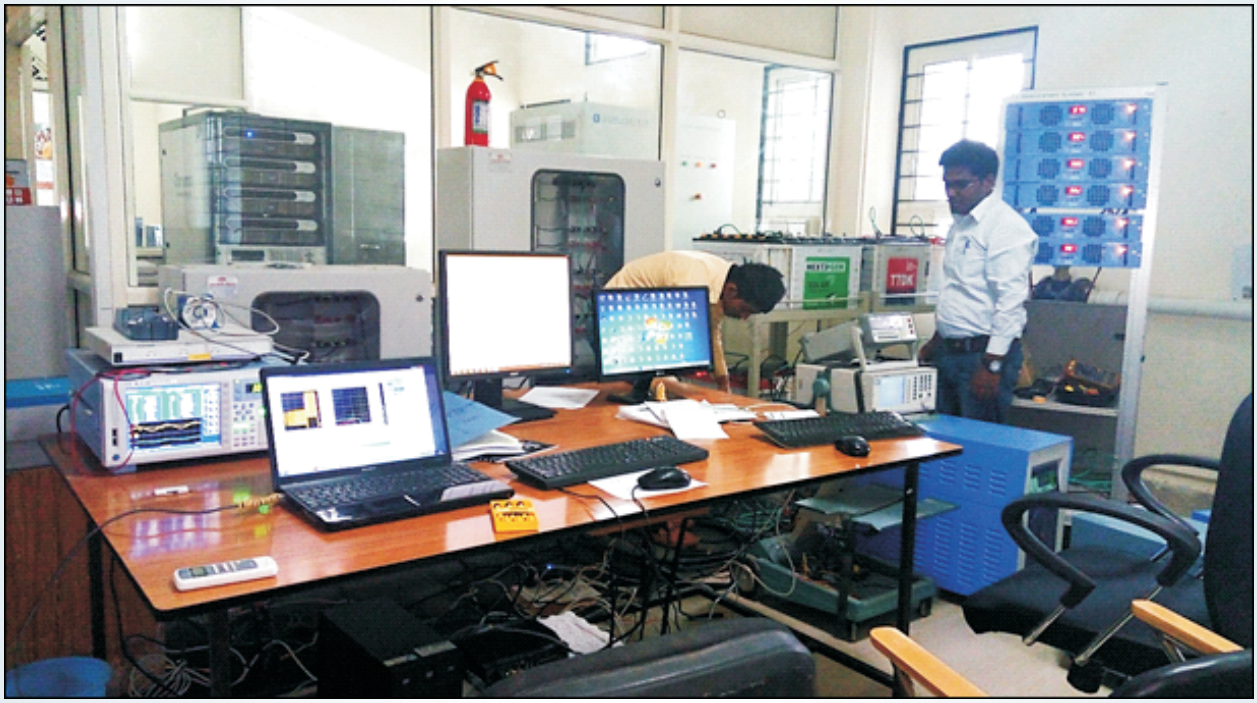


Fig. Power Electronics Lab

1.2. Name of tests and Standard for testing of PV inverters:

PV inverter/ PCU ➢ Safety of power converters	• General requirements (GI/ standalone/ other) • Particular requirements of inverter	⊕ IEC 62109-1 ⊕ IEC 62109-2
➢ Installation & Commissioning	• Parallel operation of inverter • Islanding protection (All except standalone inverter)	⊕ IEC 61727 ⊕ IEC 62116
➢ Procedure of measuring efficiency	• Procedure for measuring efficiency (GI/ OFF-GRID/ ROOF TOP) • Measuring the efficiency of MPPT algorithm and overall system efficiency of Grid interactive inverter	⊕ IEC 61683 ⊕ EN 50530
Charge Controller ➢ Charge controller/ MPPT units	• Battery charge controller for photovoltaic system	⊕ IEC 62509
➢ Power conditioners/ Inverters including MPPT and charge controller	• Environmental testing	⊕ IEC 60068-2 (1, 2, 14, 30)

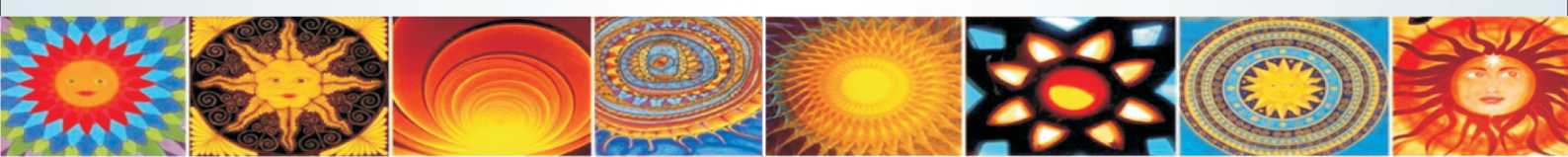
1.3 Details of the customers

About 20 systems of the following manufacturers were tested at NISE from April 2015 to March 2016 according to the standards given in the Table 1.2:

1. M/s G1 Energy Solutions Pvt Ltd
2. M/s Cyber Power System Pvt. Ltd
3. M/s Emeral Energy Solution Pvt. Ltd.
4. M/s Mitramax Energy Pvt Ltd
5. M/s Kisan Solar (Pump Controller)
6. M/s Fujiyama Power Systems (UTL)
7. M/s Outback Power
8. M/s Statcon Powtech Pvt. Ltd.
9. M/s Vasavi Electronics

1.4 List of Instruments for Testing:

The following instruments are used for testing and performance evaluation at NISE:



S.no.	Equipment	Quantity	Model/Make	Status
1	Solar Array Simulator 15 KVA	4	TERASAS (AMATEK)	Working
2	RLC Simulator 5 KVA	3	CHROMA	Working
3	DMM 8341	4	8341	Working
4	DMM 8255	1	8255	Working
5	Grid Simulator 6 KVA	1	CHROMA	Working
6	DPO	2	TEKTRONICS	Working
7	Power Analyzer (Four Channel)	1	ZIMMER	Working
8	Sensor Source Unit	1	ZIMMER	Working
9	CRO	1	2221A TEKTRONICS	Working
10	Power Analyzer (Six Channel)	1	YOKOGAWA	Working
11	Anti-Islanding Testing Device	1	Actual RLC Load 60 KVA	Working
12	Environmental Chamber	1	BALLICE	Maintenance

1.5 International co-operation/joint projects

Under the NISE- PTB joint project activity power electronics lab collaborated with Fraunhofer ISE. With a view to improve the quality and certification procedure for inverters, PCU, charge controller etc. It is expected that the accuracy repeatability and reliability of the measured data on the samples would improve substantially

2 Research work during 2015-16 by Power Electronics Lab group

Under the research carried out by NISE the following papers were accepted for publication in different International Conferences

- **Weighted efficiency of SPV power converters/inverters in Indian composite climate by** Kamlesh Yadav, O.S. Sastry, B.Bora, M.kumar, R.Singh, R.Parmar, Atul Kumar , B.Prasad, 32 EUPVSEC

- **Performance Comparison of three Inverters with different Transformer topology, by** Mithilesh Kumar, O.S. Sastry, Kamlesh Yadav, Richa Parmar, Rashmi Singh, Brinchi bora, 32 EUPVSEC

- **Selection of weather profile(s) for testing performance of SPV Pumps in Indian climate by** Kamlesh Yadav, O.S. Sastry, B.Bora, M.kumar, R.Singh, Atul Kumar , B.Prasad, 32 EUPVSEC

1.3 BATTERY CHARACTERIZATION LAB

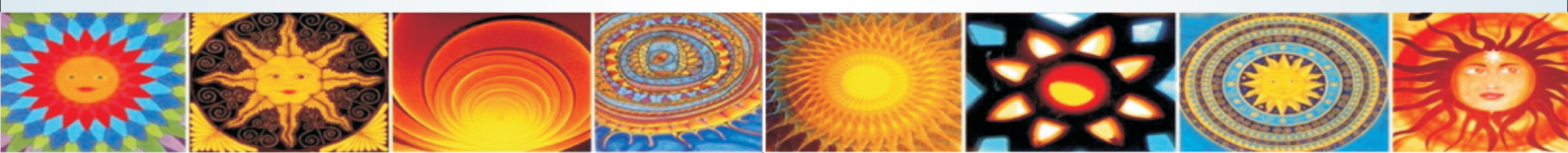
Introduction:

The batteries are characterized as "last line of defence" for SPV power applications. A malfunctioning battery not only increases the recurring cost of the system but can also lead to safety hazards. Hence it becomes inevitable that the products being used in open market are properly examined for various parameters. The Battery Characterization Lab at NISE has been entrusted with the task to maintain and promote quality back-ups for SPV applications and since its inception the lab has been instrumental in its endeavours.

The Battery Characterization Lab at NISE incorporates a comprehensive set-up to carry out testing and certification of major secondary battery storage technologies. The Lab is committed to serving the energy storage community and the national interest with cutting-edge research programs, the highest quality testing results, and leadership in battery safety and reliability. Through its state-of-art setup the lab is serving battery/cell manufacturers by providing excellent service at nominal cost as compared to other testing laboratories. Manufacturers are also advised on best practices to produce long lasting and efficient products. The prime testing equipment is Bitrode make Life Cycle Testing machine which is an integral of programmable power supply, load and data logger and conforms to international specifications for testing equipments. For maintaining standard testing conditions the lab is equipped with a climatic chamber having a wide range of operating temperature. The lab is also backed by dedicated SPV power plant with high storage capacity to maintain un-interruptible operations. At present, the lab is providing service to various manufacturers and all secondary batteries technologies are being examined such as lead-acid, Li-ion (all salts), NiMH, NaS and NiCad.

The objectives of the battery characterization lab are:

- Study of various factors that lead to energy storage system safety and reliability incidents
- Promoting use of new storage technologies and new materials to improve overall energy storage system safety and abuse tolerance,
- Developing and performing new tests/standards to ensure high quality product
- Performing detailed failure analyses,
- Supporting industry to take-up high quality manufacturing process,
- Imparting training for proper installation and maintenance profile, and
- Developing strategies to mitigate energy storage cell and system failures



Major Test Equipments:



It consists of 8 test circuits of different capacities which are programmed through a computer for a desired charge or discharge profile.

The key parameters that can be monitored are:

- Voltage
- Current
- Ampere-hours
- Watt-hours
- Temperature
- Time
- Power

Fig. Battery Testing Module



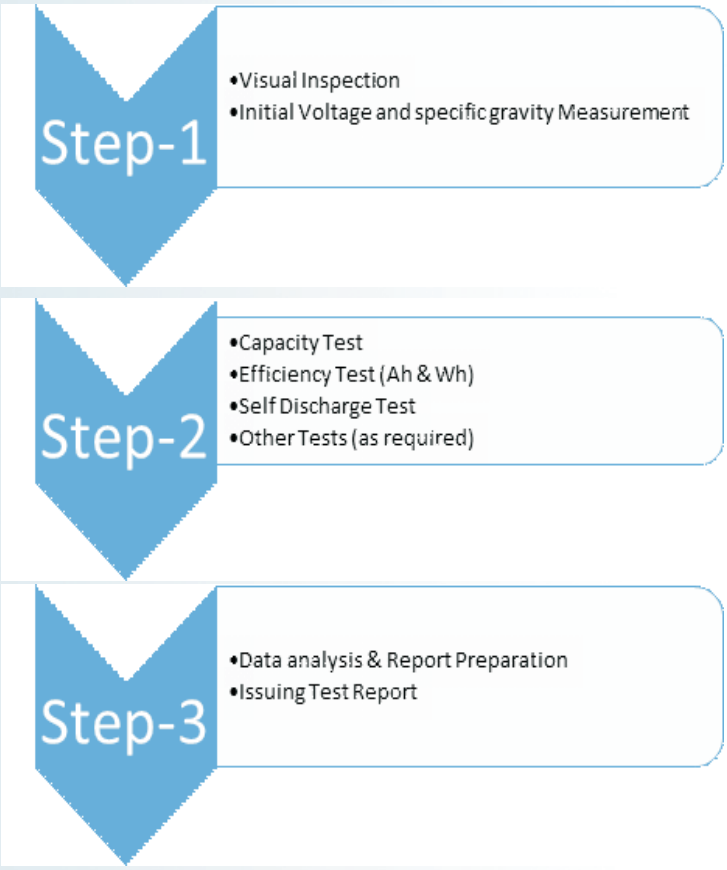
It is required to simulate standard test conditions. The operating temperature range can be varied from - 40^{0}C to + 60^{0}C. It can also be used to vary humidity parameter

Fig. Climatic Chamber

Major test facilities being offered are:

- Capacity Test
- Efficiency test
- Self-Discharge Test
- Type Test
- Accelerated Life Cycle Test
- Environment Test
- Conductance Test
- Battery Abuse Testing (under process)

Test Procedure: For routine testing the samples received at battery lab are required to endure through following sequence before being certified:



The time expended for routine test is typically 3 months. These are the primary tests that are mandatory for batteries being used in SPV applications

Samples Examined: The battery samples received and examined at battery test lab in financial year 2015-16 are as follows:

Battery Technology	Flooded Lead-Acid	VRLA	Li-Ion	NiMH	NiCad
Samples Examined (nos.)	143	28	18	10	1

Sample Description	Capacity Test	All Tests	Revenue (Rs.)
SPV Systems	115	Nil	7,57,800/-
Battery Test	17	68	26,00,600/-

Revenue: The total revenue generated from battery lab amounts to **₹ 33, 58,400/-**

Research & Development Work: Apart from routine testing battery tests lab is also engaged in different research and development projects as follows:

I. Development of Testing Profile for emerging technologies
II. Life Cycle Tests
III. Exploring Battery health analysis technique
IV. Degradation Analysis of batteries in Solar Street Lights
V. Performance analysis of E-vehicles

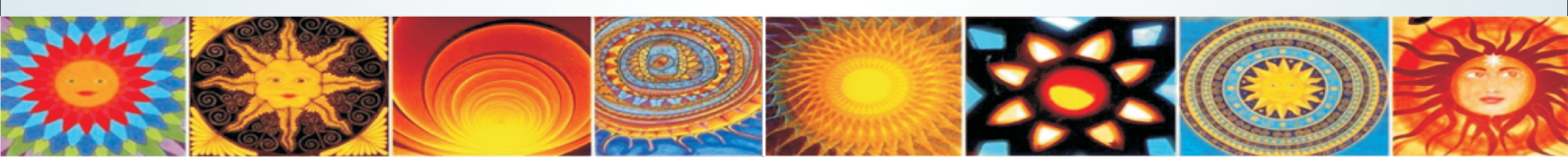
Research Reports/Publications: The research projects which are published/under review in different journals/conferences are as follows:

I. Conductance Testing of operational battery bank
II. Performance analysis of lead-acid battery at different cut off voltages
III. Effect of temperature on battery performance
IV. Performance evaluation of different technologies
V. Study of battery performance under field simulated conditions
VI. Effect of temperature on flooded lead-acid battery performance
VII. Degradation analysis of batteries in SSLS

Skill Development:

In order to share knowledge, experiences and to create awareness about significance of energy storage, battery lab provides an active participation in various training programs conducted at NISE. Through its classroom material, field demonstration and practical module, the participants are exposed to the technicalities in the field of energy storage. The regular beneficiaries of these programs include both national and international delegates. Key programs for skill development include

I. Suryamitra program
II. Defence Personnel Training on SPV technologies
III. SPV training for BSF personnel
IV. Workshop on Off-grid SPV applications
V. Specialized training on Roof-top Solar
VI. Training on grid-interactive systems
VII. Visitors program for students form schools/institutes
VIII. Training for chartered engineers
IX. Industrial visit from various institutions
X. International technology and economic cooperation (ITEC) program



1.4 SPV Lighting Systems Laboratory

Introduction

Solar Photovoltaic Lighting Systems Laboratory (SPVLSL) is engaged in testing of performance and reliability of solar based lighting system as well as validation of field performance. It is the first Solar Lighting laboratory established by MNRE to test and performance evaluation of Solar PV Lighting systems under the MNRE Programme. The MNRE later also approved other Testing Laboratories i.e. ERTL Kolkata, CPRI Bangalore, TERI Delhi for similar purposes. The Lab has been testing the products with regard to the desired quality, efficiency, reliability, ruggedness and ease of operation.

SPVLSL at NISE has been playing a vital role in development of solar lighting system and other systems for different application. It offers advice to manufactures for improving the quality and also helps in preparing the performance guideline through its testing activity. MNRE has developed technical specifications for Solar Lantern, Solar Home Lighting Systems, Solar Street Lighting system etc. These technical specification are revised regularly based on the improvement in the technology and feedback from the field. These guidelines are adopted by the manufacturers and the user agencies in their programmes. MNRE has revised the system design for 2015-16 and included Multiple level light output in solar lantern, defined more models of solar home lighting system and for street lighting systems a diming mode (first 4 hrs. at full brightness and then, rest of the time at lower light level) with motion sensor (in case any movement, it will glow to full level). Solar home system (Solar Power Pack for DC & AC model) have also been included in the MNRE Programme. The "DC Model" could be used to run a small DC fan or a 12V DC television along with 6 nos. W-LED Lamps, while the "AC Model" could be used to run AC fan and/or a television along with 6 nos. W-LED lamps which include the solar Inverter of 24V/300VA, Pure Sine wave.

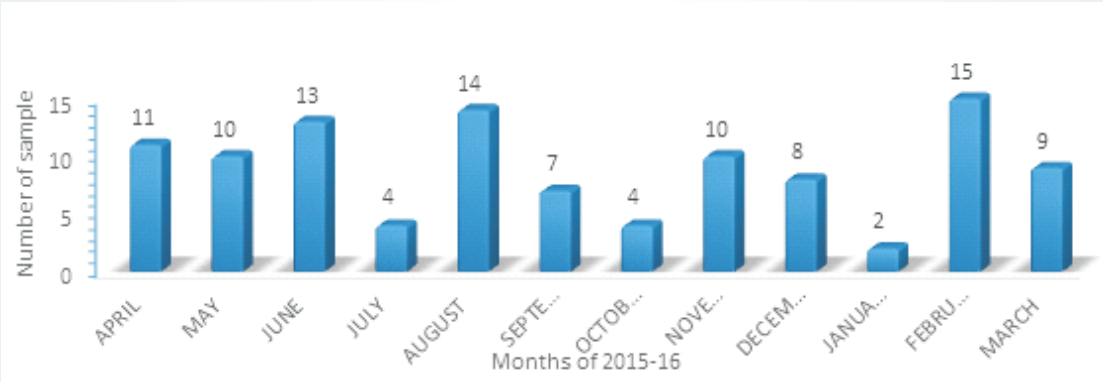


Fig 1. Month-wise number of Solar Lighting systems tested and Certified in SPVLSL during 2015-2016

107 Solar Lighting systems were tested and Certified in the laboratory during 2015-2016. Month wise break up is shown in fig. 1. The testing & certification is done against payment and month-wise revenue generated in the laboratory is plotted below in fig. 2. An Income of Rs. 30,62,313 for the financial year 2015-2016 has been generated from the laboratory.

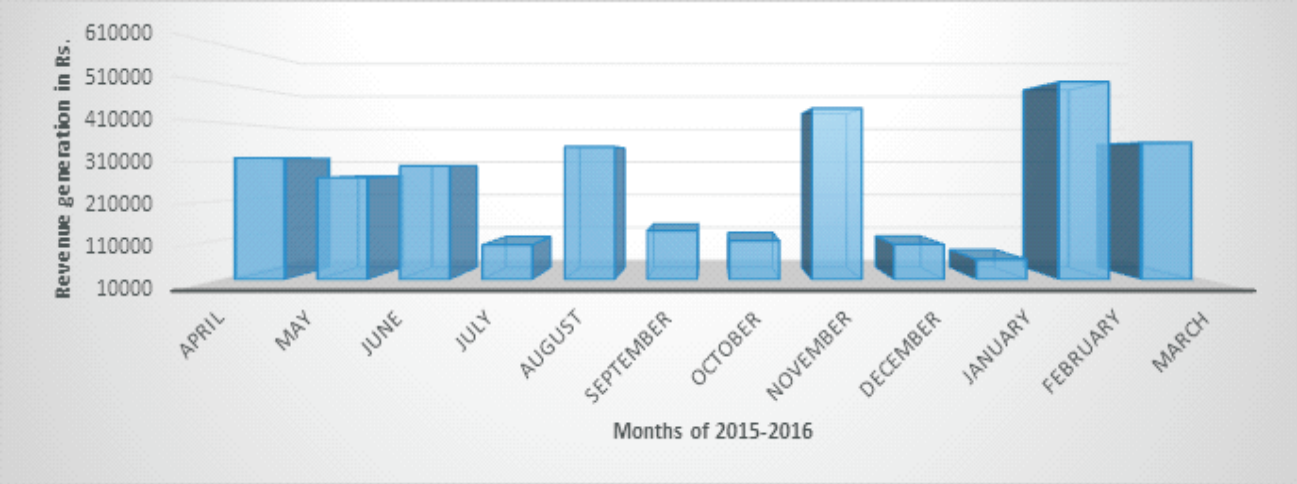


Fig. 2 month-wise revenue generated at SPVLSL in 2015-16

Standards & Technical Specification

SPVLSL performs the testing of the lighting systems as per the following technical specifications:

1. MNRE Technical Specifications for White LED (W-LED) based Solar Photovoltaic Lighting systems (Solar Lantern, Solar Home lighting system, Solar Street Lighting System, Solar Power Pack (DC & AC Model).

2. User defined Technical Specifications for other PV based system i.e. road stud, garden light, task light, study lamp, torch, solar e-rickshaw, & air conditioner etc

SERVICES & TECHNICAL SUPPORT

Following services and technical support is provided by the Laboratory:

1. Testing of Solar Lighting and other system as per MNRE specifications.
2. Testing of Other PV Lighting system as per User specification.
3. Developing technical specifications for other PV systems for different applications and their performance reliability evaluation.
4. Guiding the industry for design & development of the PV system for different applications i.e. Solar home systems for different household requirement, road studs, security lights, path finders, solar rickshaw, solar AC etc.by way of developmental testing.
5. Environmental stress testing of solar lighting system & other PV systems.
6. Guiding the state nodal agencies and other programme implanting organizations in preparation of different user defined system specification and development of the system conforming to specification.

Solar Lighting System

The last few years has seen a rapid evolution of utilization and marketing of the solar based lighting system. The consumer market has moved from CFL to LED based lighting systems with new features and replacing lead acid batteries with Lithium Ion batteries. The advent of high lumen efficiency, ultraviolet free radiation, and wide view angle white light emitting diode (WLEDs) has revolutionized the lighting technology not only by reducing the required wattage, but also increasing the operational life of the system. The cost of LED based lighting system has been reduced significantly because of lower wattage of PV module & storage capacity of battery.

Depending on the type of applications and utilization, the solar lighting system can be classified into the following categories

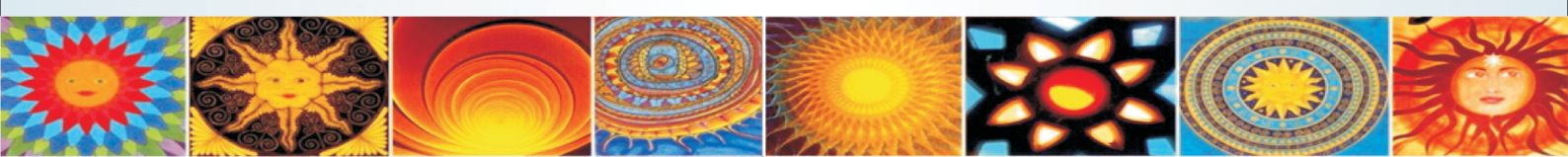
1. Solar Lantern (SL)
2. Home Lighting system (HLS)
3. Street Lighting System (SLS)
4. Solar Task Light (STL)
5. Solar Study Lamp (SSL)
6. Solar Torch (ST)
7. Solar Power Pack (DC or AC model)

Each of these systems consist of the following basic components-

1. PV Module
2. Battery
3. Charge controller
4. Solar Inverter
5. LED driver
6. Luminary to house the LED.
7. Cables and connectors.

The requirement of different components of the Solar Lighting is briefly described below

1. **PPV Module:** The PV module should be of sufficient capacity so that it may provide power to charge the battery with 120% of the discharged capacity from the battery required for meeting the daily operation of the system.
   The module wattage should be defined at 16.4 Volt and 8.4 Volt for 12 volt and 6 volt system respectively.
2. **Battery:** The battery should be sealed maintenance free (SMF) or spill proof low maintenance and must conform to BIS or equivalent International standard. The Watt –hour efficiency of the battery should be more than 80%..

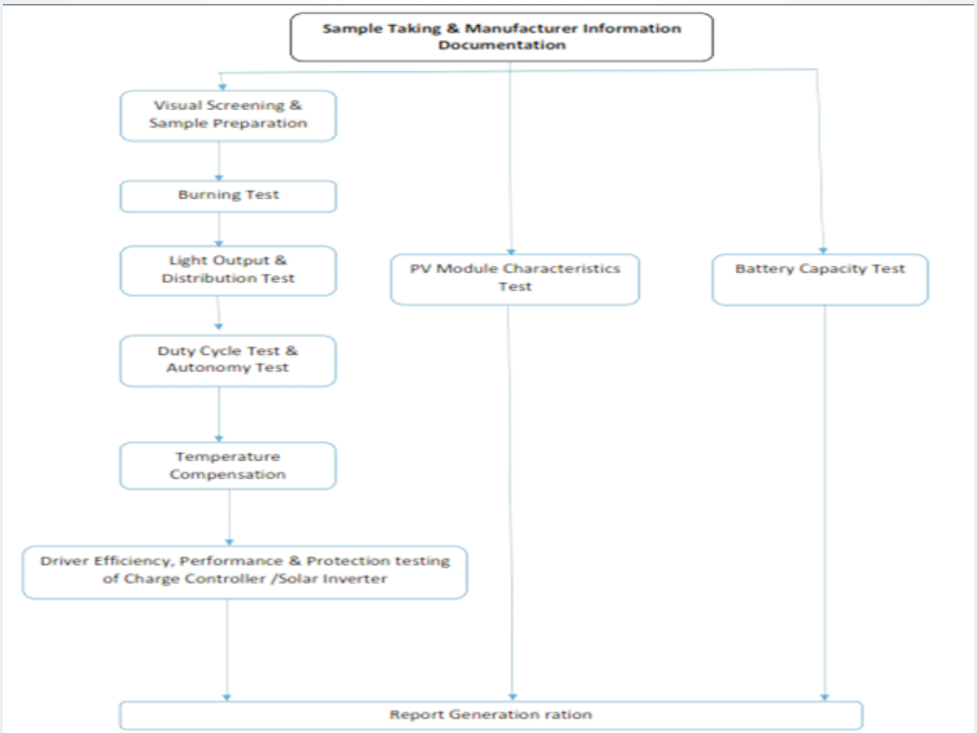


3. **Charge Controller:** It must have the temperature compensation for the battery set points i.e. LVR, LVD and BVR by using the external temperature sensors or in-built temperature sensing components. Other feature like, Short circuit protection, No load protection, Self-consumption, Battery Reverse Polarity, PV Module Reverse Polarity etc.
4. **Solar Inverter**: Solar Inverter should be a 12V or 24V/300VA, Pure Sine Wave with THD less than 5% and efficiency of more than 90%. The Idle current i.e. when there is no load & inverter is switch off, should be less than 40mA, and the voltage drop from PV Module to the battery terminals should not exceed 1.0V. Its output AC voltage should not change with the decreased battery voltage in the operating voltage range of the battery.
5. **LED Driver:** It must provide a constant current to the LEDs irrespective of the battery voltage so that the LEDs can provide the constant light during the specified hours of operation. The efficiency of the drive should be more than 85%.
6. **Luminary:** The luminary which houses the LEDs should have proper optics and diffuser so that the LEDs may provide uniformly dispersed light without dark bands / abrupt variations and soothing to eyes with minimum light losses.

Test Facility & Procedure:

The National Institute of solar energy (NISE) has established a comprehensive test facility for performance evaluation of PV lighting system in order to ensure their conformity to the MNRE specifications and to ensure smooth and reliable performance in the field.

The following are the recommended sequence of testing for Qualification testing of SPV Lighting system:



Visual Screening &Sample Preparation:

Visual Screening should be done before any other tests. In this case sample is initially inspected for its physical condition and test for its normal operation. After the visual screening, prepare the sample for further testing by partial disassembly to provide easy access to various components

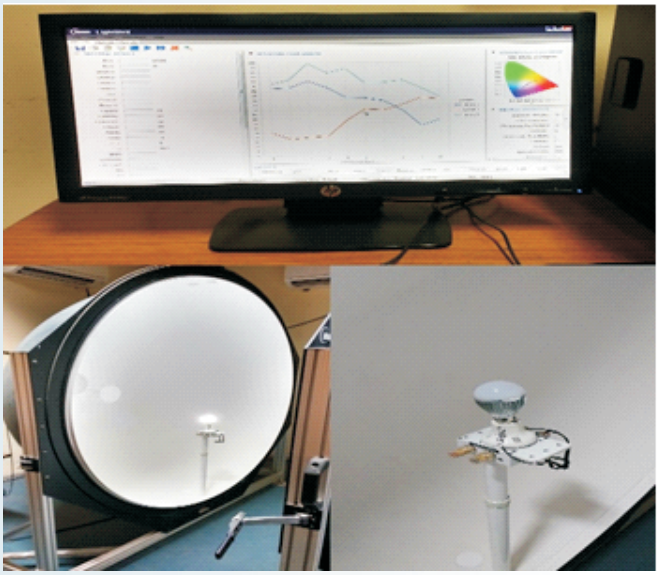
Burning Test:

During this test the system is kept ON continuously for 100 hrs. The purpose of this test is to stabilize the lumen output of the light source. However with continuous 100 hours of operation, the ruggedness & reliability of the electronic component used in the system is also assessed.



Light Output & Distribution Test:

The light output (total luminous flux or lumen output) and other light output parameters (i.e. CCT, CRI etc.) can be measured by using Integrating sphere. The light distribution can vary from one type of system to other (i.e. SL, HLS, SLS or unidirectional and Omni-directional light). The light distribution test is measured by using the LUX meter or light meter after installing the system as specified in the MNRE specification





Driver Efficiency, Performance & protection testing of Charge Controller/Solar Inverter :

The efficiency of the driver circuit is measured by measuring the input power from the battery and the output of the driver fed to the LEDs. The output of the driver circuit is then measured as a function of the battery operating voltage and the requirement to make sure the constant light output is that the driver output should not change more than ± 3% with the varying battery operating voltage

The charging behaviour of the charge controller is studied to know the type of the charge controller whether it is MPPT/PWM/series regulated/ shut regulated or any other type of the charge controller. Also the compatibility of the charge controller with the battery and the module is checked. The charging efficiency of Charge controller shall be evaluated from 10% to 100% of the rated charging current, at a battery voltage equivalent to 2.2 V/Cell ±2%.

The efficiency of Solar Inverter is measured with load having unit power factor for the power levels of 10%, 25%, 50%, 75%, 100% and 120% of the inverter's rating along with measure the THD.

To make the system fully abuse free the system is tested for battery deep discharge protection, over charge protection, reverse polarity protection, load short circuit & open circuit protection, and reverse current flow protection



Temperature Compensation:

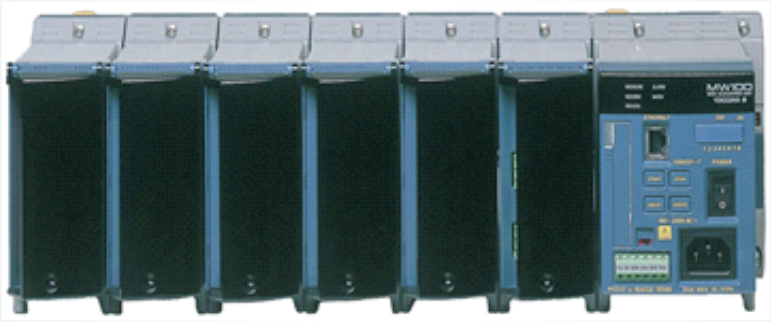
This test is conducted that the battery set points i.e. battery charge regulation (BVR), Low voltage disconnect (LVD) and Automatic load reconnect (LVR) are having the temperature compensation for proper charging of the battery irrespective of the operating temperature

For this test the charge controller is kept inside a chamber and these battery set points are measured in temperatures ranging from 0 to 50 °C



Duty cycle & Autonomy test:

This test is conducted to make sure that the PV module provided along-with the system and the charge can put the adequate ampere-hours (AH) capacity inside the storage battery on the daily basis for operation of the specified number of hours of operation in the night

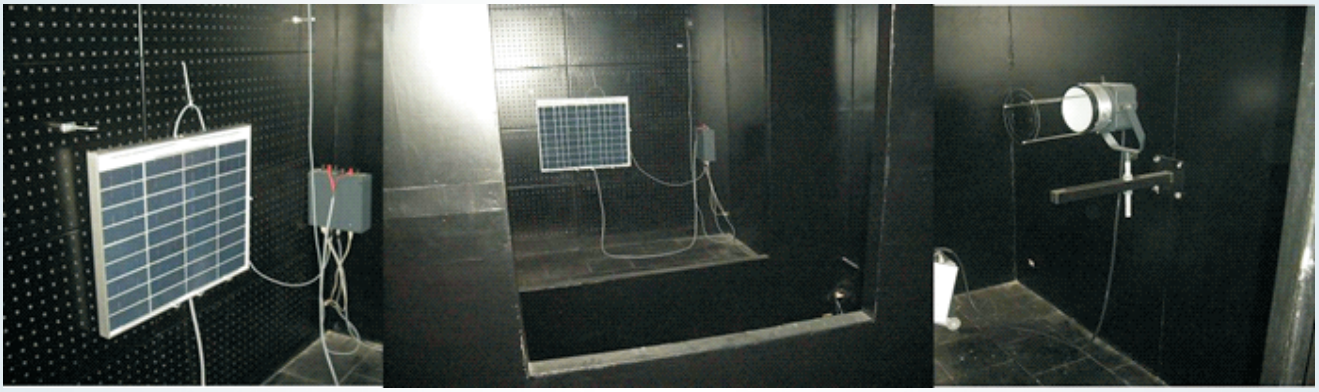


And to verify the battery runtime/autonomy, first the battery of the system is fully charge and then the system is kept ON till it is automatically OFF. The duration from ON to OFF condition of the system gives the battery runtime/autonomy

During these tests the Solar Radiation, PV module Voltage & current, Battery voltage & current, Load Voltage & current are plotted & monitored continuously using data logger system.

PV Module Characteristics Test:

The PV module submitted along with the sample is tested for its standard test condition (STC) performance by using the Sun Simulator is order to verify the claimed wattage of PV module. Before making the STC performance the module is exposed to outdoor sun light equivalent to seven normal sunny days



Battery Capacity Test:

During this test the capacity of the battery is tested at the discharge rate at which the battery capacity is rated by the manufacturer by using Battery Analyser.
To perform the complete testing of the solar lighting system and preparing the final test report it takes more than 25 days.



Research Paper:

1. Shishuranjan, Rajesh Kumar, Avinash Kumar Haldkar, Nitin Kumar Chourasiya, Experimental Evaluation of LED Based PV Street Lighting System for rural application, International Conference on Technological Drift in Mechanical & Automobile Engineering, 19-20 February, 2016.

2. Adarsh Kumar, Chandra Shekhar Sharma, Rajesh Kumar, Avinash kumar Haldkar, Testing, Performance and Reliability Evaluation of Charge Controllers for Solar Photovoltaic Home Lighting System in India, International Journal of Engineering Research, 5(1): 6-10, 2016

1.5 SOLAR CELL CHARACTERIZATION AND OUTDOOR MODULE TESTING GROUP

1. Introduction:

Solar Cell Characterization and Outdoor SPV Module Testing Group at NISE has been focusing on carrying out the research & development, testing on SPV modules, energy and power evaluation at STC (1000 W/m2, 250C cell temperature, Air mass 1.5) and of different environmental and economic performance, cooperation with the institutions & industries, along with testing & standardization. Long-term vision of NISE is to establish expertise in measurements, characterization, reliability engineering and scientific computing in solar photovoltaic technology. There are three different labs under this group: viz. Solar Cell Characterization Lab, Outdoor Module Testing Lab, and Outdoor Module Performance & Reliability Lab. In 2015-16 several research activities were initiated in this Group resulting in publication of 15 research papers in National/ International Scientific Journals and Conferences.

1.1 Solar Cell Characterization Lab:

Solar Cell Characterization Lab is a well-equipped lab for C-Si technologies testing up to 6 inch x 6 inch solar cells. The performance test of solar cell at STC, at different temperature and irradiance condition as per IEC 60904-1:2006/IS 12762 (Part-1) is being carried out at NISE. The facility has an ORIEL's class AAA "SUN Simulator" which provides a continuous steady state source and an electronic load capable of testing solar cells. The spectrum of the source qualify IEC 60904-9; 2007 Edition, or ASTM E 927-05 standards. The current - voltage (I-V curves) measurements, both dark and light conditions of solar cells is studied at different intensities and temperatures. In 2015-16, steps for up-gradation of the calibration facility for 6 inch X 6 inch solar cell were taken. The study on calibration of the 2 inch x 2 inch solar cell is in progress. The uniformity of the solar simulator light source and various other calculations for up-gradation in the calibration has been developed. The estimation of uncertainty and the way to reduce it for the calibration of solar cells is under progress. The Solar Cell Characterization Lab has organized a workshop on "Secondary reference cell calibration" a joint effort of PTB Germany & Fraunhofer Institute for Solar Energy Systems ISE, Germany and NISE.

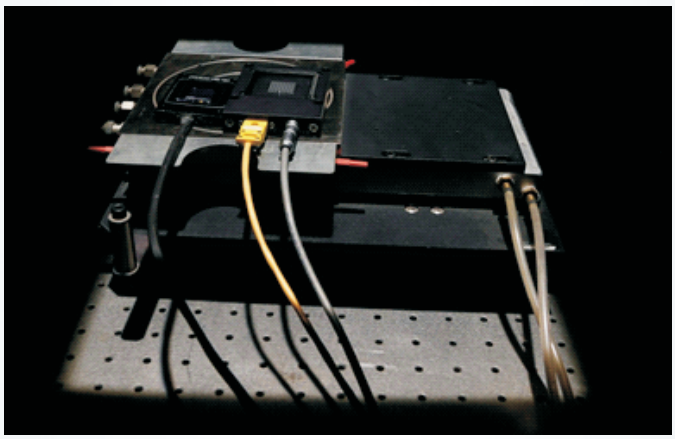


Figure : Test set-up of Solar Cell Characterization facility

The main area of concern in this workshop was the calibration of 6 inch X 6 inch solar cells procedures and its Traceability

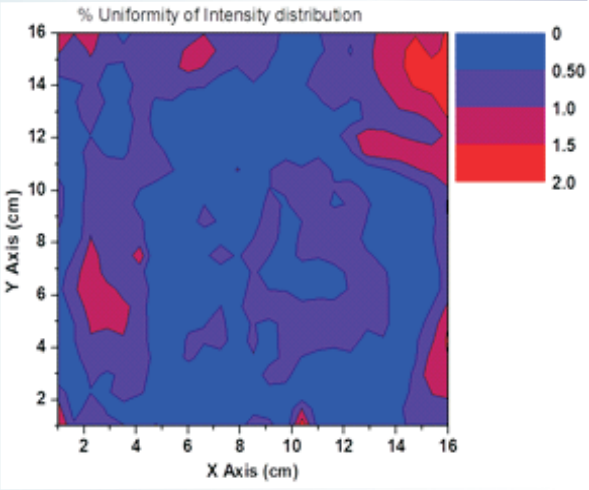


Figure 2: Distribution of change in uniformity of light in percentage with mean value for the whole area of solar

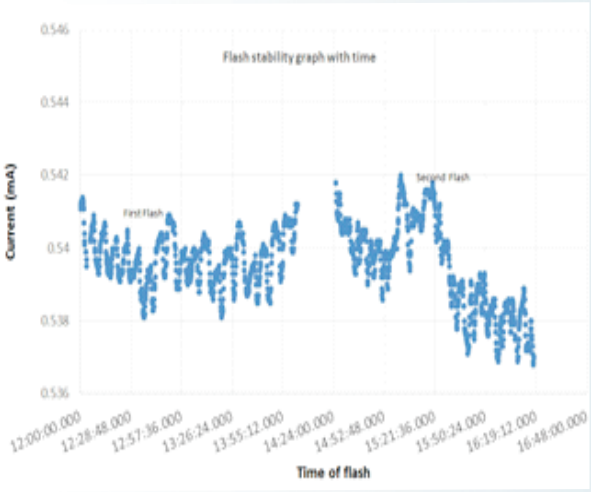


Figure 3: Flash stability of two continuous flashes in terms of currents measured

1.2 Outdoor SPV Module Characterization Lab :

NISE has an outdoor Photovoltaics modules characterization facility comprising of test equipments and set-ups for determining the energy rating of crystalline silicon as well as thin film PV Modules as per the International standards such as IEC 61853 (Part-1) and IEC 60891 (Edition 2.0), IEC 61829. I-V measurements on SPV modules under outdoor conditions, close to STC, are performed by using a mounting structure which can track the sun. Long term performance and stability of different PV technologies arrays is also conducted under various weather conditions. Using an I-V tracer (PVPM) measurements are performed continuously, at preset intervals. PVPM enables the measurement of I-V-curve of single photovoltaic module as well as of string of modules. The accuracy of the instrument is about ±0.5% which is quite high.



Figure 4: Radiation sensor used in PVPM

The outdoor testing of PV modules consist of following tests

- Visual Inspection
- Maximum Power determination
- Low irradiance performance
- Long term module performance and stability
- Outdoor median performance

1.3 Outdoor PV Performance & Reliability

Long-term reliability of SPV modules is very important for the commercial success of SPV technology, as it is one of the key factors that affects the cost of SPV generated electricity. Reliability and life time of SPV modules depends upon its degradation under real outdoor conditions. Therefore studying and understanding degradation of SPV modules is of utmost importance. The studies on the degradation and failure mechanism are often based on accelerated degradation experiments. In these experiments stresses such as radiation, temperature, humidity, and UV radiations are applied to SPV modules in a controlled environment. These tests have been found to be very useful in identifying the failures and improve the module designs. However, it is not possible for the accelerated degradation tests to reproduce all the defects and degradation mechanisms identified during the outdoor exposure. This is due to the different reaction rates and the combination of different mechanisms which may take place during real-time field exposure

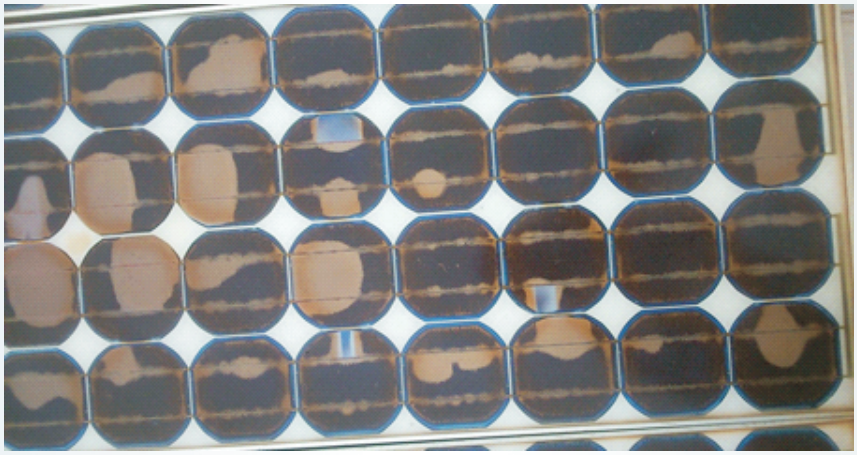


Figure 5: Long term field aged degradation in SPV module

A. Mono Crystalline Test bed

The 15 kWp mono crystalline test bed consists of modules supplied by 11 different manufacturers. This test bed was installed at NISE in 1999. Initially test bed was established with 25 kWp (10 kWp tracking + 15 kWp Fixed tilt). After long term exposure some of the modules were removed and now only 15 kWp mono-crystalline PV modules have been installed at fixed tilt structure (at 280) which are currently operational and monitored on regular basis.

B. NISE - AIST Test Bed

To study the effect of environmental parameters on different PV technologies AIST, Japan and NISE started a project at NISE in October 2009. The three different cell technologies from Japan are used in the test bed at NISE. These are multi crystalline silicon (mc-Si) (1.6 kWp), amorphous silicon (a-Si) single junction (1.2 kWp) and HIT (Hetero junction with intrinsic thin layer) (1.68 kWp). These modules are installed at a fix tilt (28°) equal to latitude of the site. The data of solar irradiance (tilted at latitude and horizontal), module temperature, ambient temperature and other parameters are logged (through CR1000 data logger) once every minute where as I-V data of each PV technology is logged (through CR1000 data logger) once every ten minute. A comprehensive weather platform along with PV array analyzers was installed to record climate change on test bed area in year 2009. The data parameters recorded at the weather station are Global solar radiation at module tilt and horizontal surface, spectral distribution of solar radiation (MS-710 and MS-712 Spectrometer), wind speed and direction (Anemometer), relative humidity and temperature

(Humidity and temperature sensor), solar UV radiation (UV radiometer), atmospheric pressure (Pressure sensor) and dew monitor unit. All the data is saved on per minute basis.

C. CdTe Test Bed Facility

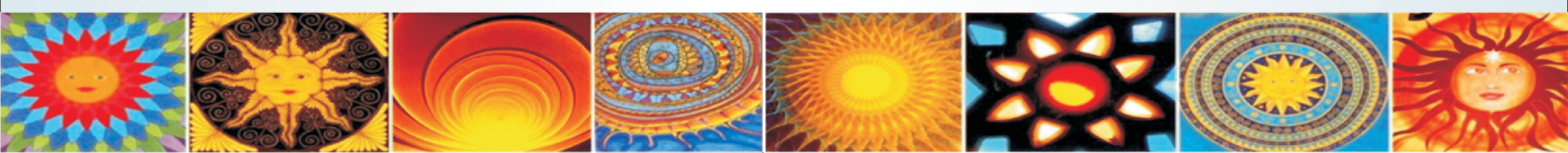
CdTe Test Bed was installed along with a weather monitoring station in June, 2012 at the outdoor SPV test bed facility of NISE under the joint collaboration project between NISE, India and M/s First Solar, USA. This test bed consists of 40 CdTe modules joined together in 4 parallel strings; each string consists of ten modules in series. The capacity of this test bed is around 3.2 kWp. All the modules were mounted on fixed mounting structure at a tilt angle 20° facing south. The output of whole of the array was fed in to a 3.3 kVA inverter and generation data is logged and measured data is saved in a CR3000 data logger. CdTe test bed consists of a weather monitoring station and CR 3000 data logger from Campbell Scientific. Pyranometer (Make: Kipp & Zonen, CMP11, error <10 W/m2); combined sensor for measuring pressure, humidity, precipitation, temperature, and, wind speed & direction, (Make: Vaisala, WXT 520, accuracy wind speed ±3% at 10 m/s; wind direction ±3°; rainfall 5%); T-type thermocouples are used to record individual PV module temperature. The data monitoring system was installed along with CdTe test bed in July 2012. This monitoring system has been crucial for identifying and correcting performance problem and has greatly enhanced the educational value of SPV array. The data of irradiance (at a tilt of 200 and horizontal), module temperature, ambient temperature, wind speed, wind direction, humidity and I-V data are logged regularly after ten minutes of time interval.

D. CIGS Test bed Facility

This is also a joint collaborative project between NISE, India and M/s Stion Corporation, USA. CIGS arrays were installed at NISE in Jan 2013. The total capacity of CIGS test bed is 1.25 kWp. Each module having peak power 125 Wp and 10 modules are connected in series. The power generation data is monitored by Grid interactive type inverter. The modules are installed at fixed structure and tilted by 21°. CIGS modules are connected with a 2.2 kVA inverter. The power generation data is continuously stored in the PC.

E. Sun Power Test bed

The Sun Power Test Bed was installed at SPV outdoor test bed facility of NISE in January 2013. The Sun Power array consists of 5 modules all connected in series with each module rated of 327 Wp, thereby making an array of 1.6 kWp. The performance is measured on regular basis. I-V data measured on continuous basis on regular intervals by using I-V tracer, PVPM 1110C.



F. Micro-morph PV Test Bed at NISE

A grid connected test bed of micro-morph based thin film PV technology has been commissioned at NISE in collaboration with Tokyo Electron Limited (TEL Solar) Japan in April 2014. The rated capacity of the test bed is 4.4 kWp having four strings consisting of 40 modules, each of 110 Wp rated capacity. The test bed consists of two SMA inverters, four thermocouples for module and ambient temperature, two reference cells, one Pyranometer, anemometer, wind vane, humidity and rainfall sensor along with the array.

2. 500 kWp multi technology power plant

NISE is installing a 500kWp multi technology solar photovoltaic power plant to meet the energy requirement in campus throughout the day, and provide the R & D infrastructure to study reliability of SPV module of different technologies on Grid and off-Grid configuration in composite climatic condition and study the smart grid design. The power plant consists of five different technologies and split into two configuration where 200 kWp connected to battery bank and the remaining 300 kWp is connected directly to grid. The details of PV technologies and configuration are given below:

Five Different Technologies and Configuration of Plant

I. 100 kWp Battery Back-up SPP with Multi-crystalline modules
II. 100 kWp Battery Back-up SPP with Panasonic HIT(C) modules
III. 100 kWp Grid Tied SPP with CdTe modules
IV. 100 kWp Grid Tied SPP with CIGS modules
V. 100 kWp Grid Tied SPP Maxeon© Sun Power with single axis Tracking

Description of the five Power Plants:

I- Multi-crystalline modules (Off Grid)

A 78 kWp power plant based on multi-crystalline modules will be connected to 2000 Ah battery bank. The plant consists of a total of 312 nos of modules of 250 Wp each. The modules are mounted at 20° fixed tilt to obtain the maximum radiation throughout the year. To get the desired power total 26 nos. of string have been erected with a combination of 12 modules in series per string and further connected to two string combiner boxes, the output will be connected to a 100 kVA Battery Inverter.

II. Panasonic HIT (Heterojunction with Intrinsic Thin-Layer) modules (Off Grid)

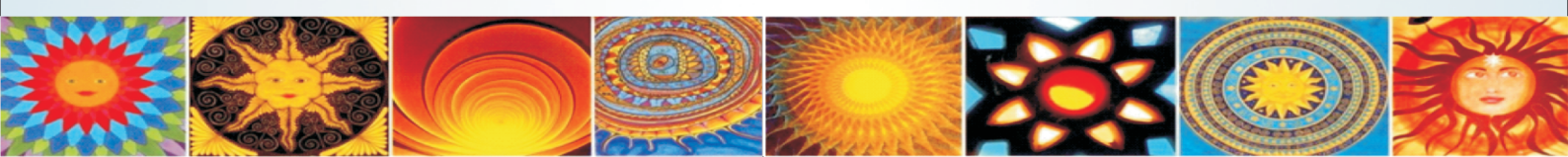




Figure 6: 100 kWp Battery Back-up SPP with Multi-crystalline modules



Figure 7: 100 kWp HIT Power Plant

HIT solar cell is a hybrid solar cell, composed of a single-crystal silicon wafer surrounded by layers of thin amorphous silicon. 100 kWp Panasonic HIT modules shipped from Malaysia are being used in this project. 420 modules have been used at a fixed inclination of 20°. HIT based power plant is also connected to battery bank of 2000 Ah. Two combiner boxes are used to club the power output. There are a total 60 strings with a combination of 17 modules in series per string.

III. CdTe modules (On Grid)

1000 Nos of CdTe Modules of First Solar, USA series 4 PV modules of 100 Wp each have been installed. Two combiner boxes are used for this power plant. In combiner box 1, 14 modules are connected in series and 11 modules in parallel, and for combiner box 2, 14 modules are connected in series and 11 modules in parallel.



Figure 8: 100 kWp CdTe Power Plant (On Grid)

IV. CIGS modules (On Grid)

The Stion Corporation from USA have supplied the CIGS modules of 100 kWp modules with module peak wattage around 140 Wp. The modules are Potential Induced Degradation (PID) resistant and have low Light Induced Degradation (LID) effects. In combiner box 1, 10 modules are connected in series and 36 modules in parallel. Combiner box 2 has 10 modules connected in series and 36 modules in parallel. All these modules are installed at fixed structure at 20° tilt.



Figure 9: 100 kWp CIGS modules (On Grid)

V. Sun Power High Efficiency modules (On Grid)

Sun Power E20 modules have been reported to have highest commercially available efficiency in the market today. The E20's have low voltage temperature coefficient, anti-reflective glass and exceptional low-light performance attributes to outstanding energy delivery per watt peak. Total 308 nos of modules of 327 Wp capacity each have been mounted on single axis tracking system equipped with advance weather monitoring system to sense the wind speed. The plant reshapes itself to its safer position when the wind speed goes beyond 160 kmph. The mechanism will be achieved with sensor fitted at the centre of the plant which is basically connected through radio frequency signal to the wind fan and its control system. The power plant is connected through two combiner boxes. Each Combiner box has 14 modules in series and 11 modules in parallel.



Figure 10: 100 kWp Sun-Power Power Plant (On Grid)

2. Smart Grid Configuration

There are five different technologies and modules of each technology will be connected to a 100 KVA inverter. A dedicated load will be connected to the battery bank. The system is being created in such a way that during the non-availability of grid, battery connected power plant will work as a reference grid. The load management will be done by SCADA. The smart grid schematic diagram is shown in Figure 11

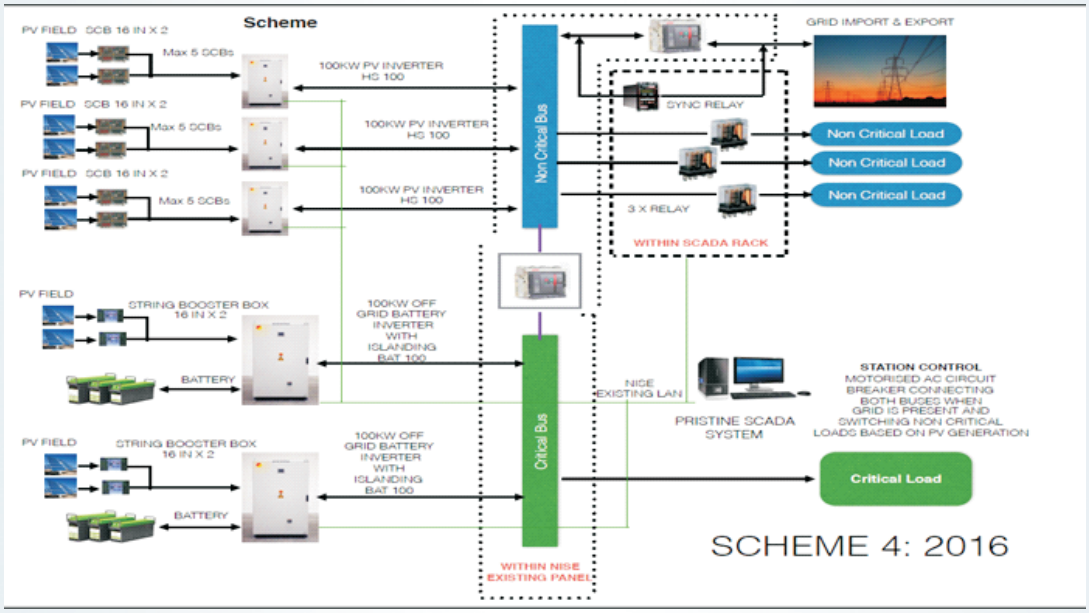


Figure 11: Smart Grid Schematic diagram

3. National/International co-operation/joint projects

3.1 Secondary reference solar cell calibration:

NISE is closely working with PTB-Germany, Fraunhofer Institute, Germany and IIT Bombay and NPL to develop a secondary reference solar cell calibration facility in the country. Under this project a Round Robin testing of secondary reference solar cell between NISE, IIT Bombay and Fraunhofer Institute has been completed. Already NISE has organized two workshops with PTB Germany in this regard. The second round robin of 5 inch X 5 inch solar cell will be initiated during 2016-17. The uncertainty estimation and its optimization has been taken up with help of Fraunhofer Institute. Standard operating procedure for calibration of solar cell is under preparation.

3.2 Performance comparison of thin film module at India and USA:

National Institute of Solar Energy and NREL, USA have embarked on a project to compare the performance of sister thin-film modules deployed in India and in Colorado, USA. NISE purchased a set of modules and shipped a subset of these to NREL. The thin-film modules were deployed in real outdoor condition in December 2013. The modules were then deployed outdoors where they were individually maximum power point tracked. Current-voltage (I-V) curves were measured at a regular interval of time. Back of module temperature, ambient temperature and irradiance were recorded along with each I-V curve. To investigate outdoor performance, IV curve data were filtered to eliminate curves affected by passing clouds, snow covered modules, irradiance outside the range of 900–1000 W/m2, and high angle of incidence. The filtered data was then corrected to an irradiance of 1000 W/m2 and module temperature of 25°C. Most of the modules are found to be underperforming compared to their name plate rating. CdTe and Micromorph module performs better in the summer seasons than CIGS. It is also observed that the temperatures coefficient data estimated at NISE is different from that of the data provided by the manufacturer. The variations in the power outputs of modules from winter to summer are mainly due to variations in the FF and PR values. These studies are conducted at outdoor conditions of NISE which is a composite climate. For other climatic conditions in India such as the arid desert zones and high humid coastal regions the performance will be somewhat similar. The annual rates of degradation in these technologies are still to be evaluated. However, at this stage given the present data it can only be concluded that CdTe and Micromorph technologies are likely to generate more energy than CIGS in most of the regions of the country. In future the long term performance will be analyzed to find out the degradation, stability and reliability of these thin film modules.

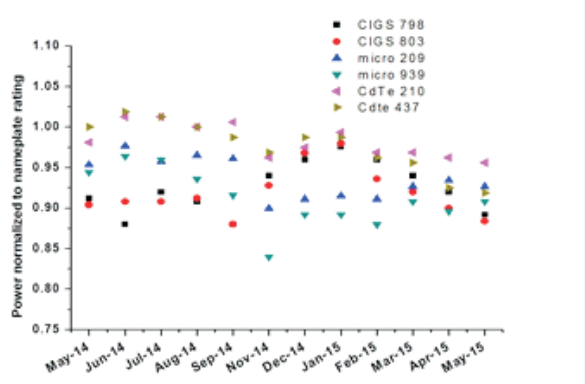


Figure 12: Yearly data of power normalized to nameplate rating

3.3. All India Survey of PV module (2014-15, 2015-16), a joint project between Solar Photovoltaic Division, NISE and NCPRE, IIT Bombay

This a joint project between NISE and NCPRE, IIT Bombay to study the field performance of SPV modules installed over a period of time ranging from 20 years to recent installations in different climatic conditions in India. These data are needed to understand reliability and process of degradation of PV modules under Indian field conditions. Although the modules qualify IEC 61215, 61646 and 61730 standards, due to the diversity of harsh climatic conditions existing in the country, the long term performance and annual degradation rates of these modules are different. This data can also be used to review and revise the existing module qualification standards and develop appropriate standards for India. The data accumulation for All India survey III (2015-16) has been completed during the year.

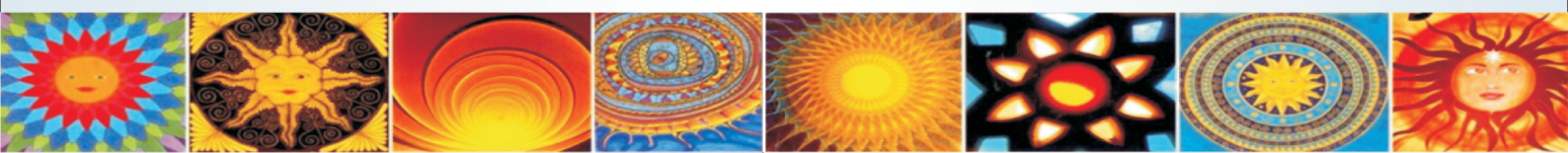
Climatic Zone	Number of Sites Visited	Number of Modules Surveyed
Hot & Dry	8	195
Warm & Humid	15	333
Composite	10	309
Temperate	6	134
Cold	6	109
Total	**45**	**1080**

3.3.1 Conclusions of All India survey II:

A total of 1080 modules belonging to different photovoltaic technologies were inspected at 45 different sites which are spread across the 5 different climatic zones of India. In this survey electroluminescence, illuminated and dark I-V measurements, insulation resistance and various other tests were carried out on SPV modules installed in the field.

The following broad conclusions can be drawn from the survey and data analysis:

- The modules with the age group of 0-5 years show high initial degradation, which may lead to warranty replacements in the long term. The degradation in these modules is mainly due to reductions in fill factor, followed by short circuit current, with negligible reduction in the open circuit voltage. Cosmetic defects are not observed in these modules.
- Modules with age group more than 5 years category also show higher than expected degradation rates, in the range of 2% per annum. The main effected parameter is short circuit current reduction, followed by fill factor, for their performance degradation
- The degradation rates of field-aged PV modules are higher in the hot climatic zones (Hot & Dry, Warm & Humid and Composite zones), as compared to the non-Hot climates.



- A significant fraction of the recently installed modules show snail trails in almost all the climatic zones, which points to material quality issues. Also scratches in backsheet, front glass and frame have been found in about 20% of the recently installed modules, which indicate improper handling during installation. The packaging materials like backsheet and encapsulant should be carefully chosen, since their early degradation would expose the solar cells to the outside environment and cause excessive power loss in due course of time

  In the field-aged modules, discoloration and corrosion have been observed in more than 70% cases in most of the climatic zones. Delamination is relatively rare, predominantly occurring in the Warm & Humid zone, and to some extent in the Hot & Dry zone. Among the thin film modules, white spots on the modules and delamination of the edge seal are most commonly found degradation modes. Some manufacturers recommend that partial shading of the thin film module should be avoided in order to prevent the white spots.

- Electroluminescence (EL) imaging studies of the PV modules in the field show that cells at the edges of the modules, particularly the bottom edge, have more cracks than the cells at the centre. Improper handling of these modules during installation could be a possible cause for these cracks. The number of cracks correlates with the degradation in the power output.

- More than 35% of the surveyed modules had hot cells with cell-to-cell temperature difference of more than 10 oC. Such modules with hot cells have been found to degrade faster than other modules. The degradation seems to be accelerated in the hot climatic zones

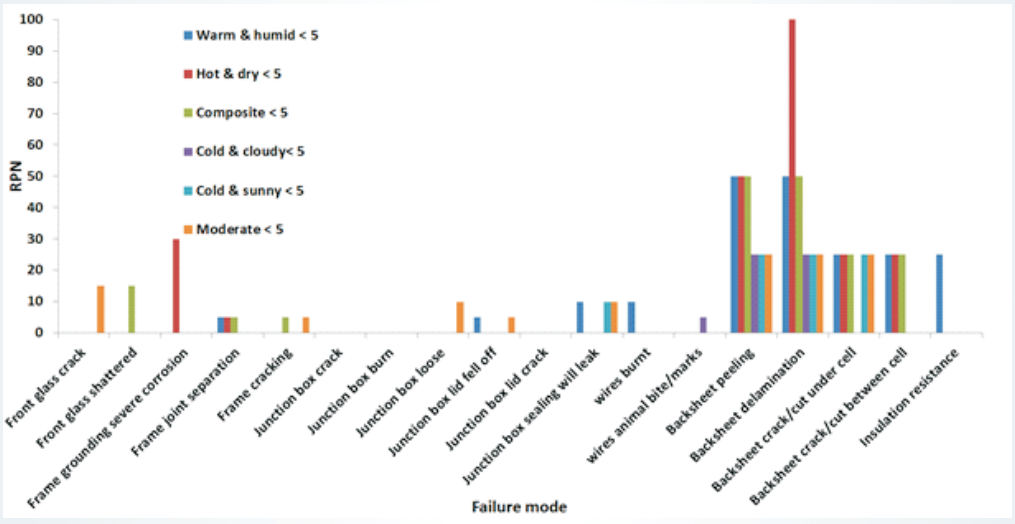


Figure 13: RPN of different climatic zones

- The analysis of dominant failure mode of C-Si PV module(s) at different climate zone of India is carried-out by using FMECA and data mining technique. This is done by calculating Risk Priority Number (RPN). In case of safety issues problem in backsheet and loose junction are the main defects in almost all climatic zones. Solder bond failure and encapsulant discolouration are the main failure mode in case of performance RPN for warm & humid, composite and hot & dry climatic zone.

3.4 SERIIUS Project:

SERIIUS is a research management plan under Solar Energy Research Institute of India and the United States corresponds to the research work package submitted to the US Department of Energy (DOE) and the Government of India in response to the US-India Joint Funding Opportunity Announcement issued in May 2011 for R&D proposals in the priority area of solar energy. Under the SERIIUS project NISE's has been involved as a Characterization Centre to carry out reliability studies. Under the activity of multi-scale modelling and reliability, the NISE is to analyze the dust effect and mitigation in different climatic zones of India.

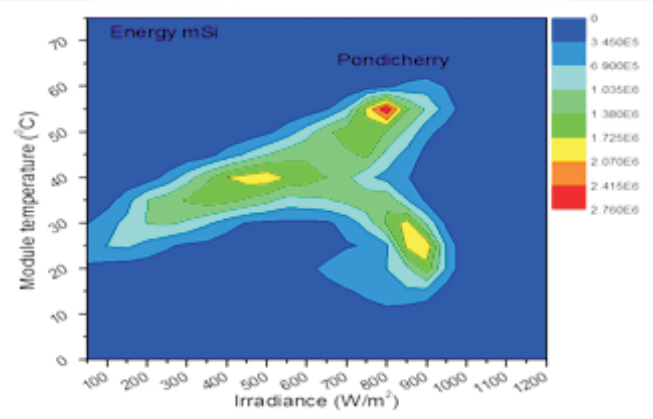


Figure : Contour map of Energy as a fiunction of module temperature and irradiation

Some of the important work done during last year

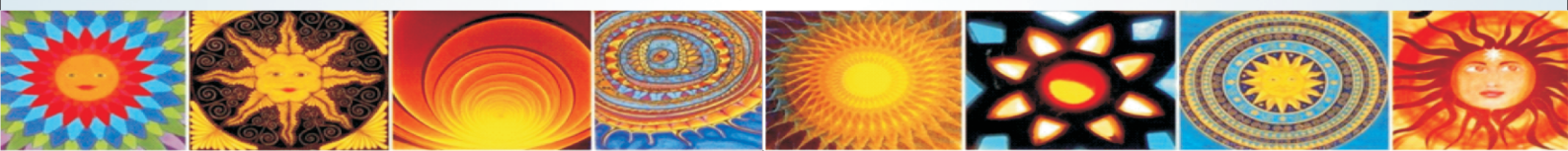
- Collaboration with ASU and NISE. Publications are planned based on RPN
- NISE exchanged databases of "Defect" and "Degradation Rate" with ASU and FSEC. These data are of c-Si PV modules from 11 Indian manufactures installed at the premises of NISE since 1999.
- Building failure/defect database based on extensive field evaluations in four climates of hot-dry, hot-humid, cold-dry and temperate
- Statistically prioritizing the risk for each defect observed in the field

- **Potential mapping of India**

  Potential mapping of PV technologies has been done by using irradiance data employing the matrix estimation method. Similar potential maps are prepared for other representative sites: Gandhinagar, Leh, NISE, Jodhpur, and Chennai

Climatic zone	a-Si (kWh/kWp)	HIT kWh/kWp)	m-Si (kWh/kWp)
Composite	1525	1554	1467
Hot and dry	1640	1690	1595
Cold & sunny	1316	1249	1292
Warm & humid	1557	1619	1530

Table 2: Potential of PV technologies in different zones



4. Publications, Technical Reports and research papers

4.1 All India Survey of PV module Report-2014

This report consist of overview of All-India Surveys of PV Module Degradation undertaken in 2014-15 under the project of NISE and IIT Bombay, together with a brief review of the relevant literature. The survey methodology, types of inspections and measurements undertaken, and the details of the equipment used in the field have been described. The degradation and different failure modes are explained as per the age and climatic zones for different PV technologies. This report has already been published.

4.2 Reliability of Photovoltaic Modules: A NISE Report

A draft report summarizing the work carried out on the performance and reliability of PV module at NISE has been prepared. The report also describes the methodology to analyze the reliability and performance of PV module.

4.3 STAPP project report

STAPP is an Indo-UK consortium project and NISE is a partner in it along with other research institutes. The project has already been completed and a project report has been published. NISE has also contributed to the report as per the assigned work packages.

4.4 Research paper in Journals during the reported period

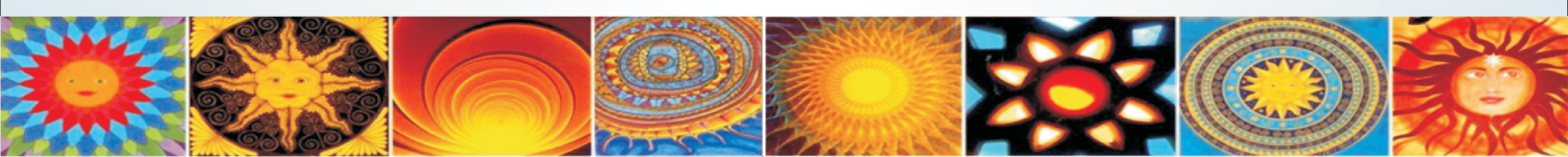
I. Magare, D.B., Sastry, O.S., Gupta, R., Betts, T.R., Gottschalg, R., Kumar, A., Bora, B., Singh, Y.K. (2015) "Effect of Seasonal Spectral Variations on Performance of Three Different Photovoltaic Technologies in India", International Journal of Energy and Environmental Engineering (IJEEE), DOI 10.1007/s40095-015-0190-0

II. Rawat, R., Kaushik, S. C., Sastry, O. S., Singh, Y. K., Bora, B. (2015), “Energetic and Exergetic Performance Analysis of CdS/CdTe Based Photovoltaic Technology in Real Operating Conditions of Composite Climate”, Energy Conversion and Management, 110,42-50

III. Sinha, A., Sastry, O.S., Gupta, R. (2015) "Detection and Characterization of Delamination in PV modules by Active Infrared Thermography", Nondestructive Testing and Evaluation, DOI:10.1080/10589759.2015.1034717

IV. Birinchi Bora, Arun Kumar, O.S. Sastry, Renu, Manander Bangar, Takumi Takashima and B. Bandyopadhyay, “The synergistic effect of Air mass on Outdoor Performance for different PV module”, 2016, International Journal of Green Energy

V. Effect of module temperature and seasonal variation analysis of the outdoor performance of CdTe at composite climate of India, Birinchi Bora, O.S. Sastry, Yogesh Kumar Singh, Ramayan Singh, Kamlesh Yadav, Vikrant Sharma, Manander Bangar, Mithilesh Kumar, Invertis Journal of Renewable Energy, Vol. 5, No. 3, 2015



VI. Potential of concentrated photovoltaic system at composite climate of India, Manander Bangar, Birinchi Bora, Renu, Rashmi Singh, Supriya Rai, O.S. Sastry, Invertis Journal of Renewable Energy, Vol. 5, No. 3, 2015

4.5 Research papers in Conference

I. Ashish Sharma, Birinchi Bora, O. S. Sastry, Yogesh Kumar Singh, Bishnu Mohan Jha, Rashmi Singh, Supriya Rai, Manander Banger, Renu, Suprava Chakraborty, Kamlesh Yadav, Dharmveer Singh, Kaushik Saikia, S.K. Samdarshi, Performance & Seasonal analysis of outdoor performance of Sun Power based MaxeonTM Technology in Composite Climate of India, 32nd European Photovoltaic Solar Energy Conference and Exhibition, Munich, Germany.

II. Yogesh Kumar Singh, Birinchi Bora, Ramayan Singh, Suprava Chakraborty, O. S. Sastry, Rashmi Singh, Supriya Rai, Kamlesh Yadav, Performance analysis of different Thin Film Module Technology in Indian Climatic Condition, 32nd European Photovoltaic Solar Energy Conference and Exhibition, Munich, Germany.

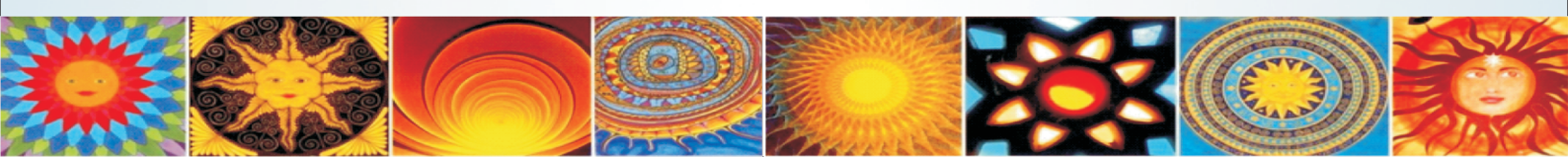
III. Rashmi Singh, Birinchi Bora, O. S. Sastry, Supriya Rai, Manander Banger Renu, Uncertainty analysis in Power Rating measurement of Solar Cell as per IEC 61853-1. 32nd European Photovoltaic Solar Energy Conference and Exhibition, Munich, Germany

IV. Supriya Rai, Birinchi Bora, O. S. Sastry, Rashmi Singh, Manander Banger, Renu,Gopal Jha, Tika Ram Khadka, Variation in Spectral transmittance due to dust on CdTe & Monocrystalline Module. 32nd European Photovoltaic Solar Energy Conference and Exhibition, Munich, Germany.

V. Birinchi Bora, O. S. Sastry, B. Prasad, Seasonal Analysis of most frequent condition and Energy Rating of PV Module Technology, 32nd European Photovoltaic Solar Energy Conference and Exhibition, Munich, Germany

VI. Dharmveer Singh, Birinchi Bora, O. S. Sastry, Yogesh Kumar Singh, Rashmi Singh, Supriya Rai, B. Pradhan, Manander Banger, Renu, Ramayan Singh, Ashish Sharma Kaushik Saikia, Analysis of different Shading Pattern on Total Cross Tide connected configuration of Solar PV Power Plant, 32nd European Photovoltaic Solar Energy Conference and Exhibition, Munich, Germany.

VII. Imon Kalyan Barua, Birinchi Bora, O. S. Sastry, Rashmi Singh, Supriya Rai, Manander Bangar, Mithilesh Kumar, B. Prasad, Studying the effect of Spectral Distribution with Seasonal and Irradiance Variations, 32nd European Photovoltaic Solar Energy Conference and Exhibition, Munich, Germany.



VIII. Tika Ram Khadka, Birinchi Bora, Supriya Rai, Rashmi Singh, Manander Bangar, Dharmveer Singh, Ashish Sharma, Kaushik Saikia, Renu, O.S Sastry, R. Arun Prasath, "Analysis of Visual Defects for Different Solar Photovoltaic Technology", 2nd National Conference on Materials for Energy Conservation & Storage, 2016, Puducherry.

5. List of M.Tech trainees working with the group during this period

Sl. No.	Name of students	Institute	Duration	Course
1.	Ashish Sharma	Central University of Jharkhand	1 Year	Integrated M. Tech
2.	Kaushik Saikia	Central University of Jharkhand	1 Year	Integrated M. Tech
3.	Dharamveer Singh	Central University of Jharkhand	1 Year	Integrated M. Tech
4.	Imon Barua	TERI University	6 Months	M. Tech
5.	Tika Ram Khadka	Pondicherry University	4 Months	M. Tech

6. Awards/recognition received during the year.

A. A paper of Ms. Rashmi Singh, JRS of this group has been selected for oral presentation in the prestigious 32nd EUPVSEC conference, Germany. The theme of her paper is the uncertainty measurement of solar cell characterization as per IEC 61853.

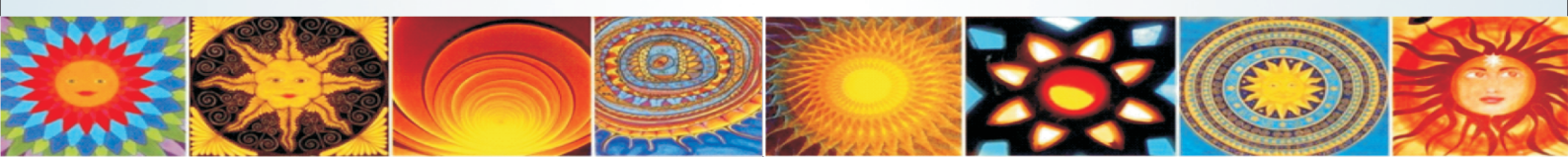
B. Mr. Birinchi Bora, SRS of this group has been selected for the prestigious SERIIUS – MAGEEP Scholarship for pursuing research at Arizona State University for 10 weeks

7. Equipments/Test setup developed.

Potential Induced Degradation (PID) Test Set-up

Potential Induced Degradation (PID) can have profound adverse impact on the financing and operating of PV plants. While the entire PV system interacts to cause PID, the failure mode occurs in the modules. The factors that enable PID (voltage, heat and humidity) exist on all photovoltaic (PV) systems, but the effect does not occur on all or even most PV systems. PID is the main concern with the safety issues related to solar PV plant with high operating voltages. The rapid growth in PV plant deployments, combined with dramatic reduction in module prices (and in some cases, module quality), has brought renewed interest in the phenomenon.

Set-up Requirements for the Experiment of PID: A test set-up is designed for PID testing with maximum six numbers of modules with a high voltage power supply (up to 2000 V), to observe the effect the safety and performance issues related with PID. An experimental set up is planned with input from Florida Solar Energy Centre, USA.



1.6 SOLAR PV WATER PUMPING DIVISION

A solar photovoltaic pumping system consists of a solar array, a DC/ AC motor and a pump unit, a controller or inverter with MPPT arrangement etc. In case of DC pumps, it can be directly coupled to the PV array, whereas in case of AC pump, an inverter is required to invert the Direct Current to Alternating Current. Nowadays, mostly two types of pumps are used in SPV water pumping system, i.e., centrifugal and positive displacement pumps. In Centrifugal Pumps, water is sucked by centrifugal force created by impeller and directed by the casing to the outlet as the impeller rotates. A positive displacement pump operates by forcing a fixed volume of fluid from inlet pressure suction of the pump into discharge zone of the pump. According to the depth of the well, SPV based pumps can be of three types, i.e., Surface, Submersible and Floating type. A surface pump which is mounted outside the fluid to be pumped draws water from shallow wells, springs, rivers or tanks, whereas a submersible pump is submerged in the fluid to be pumped. A floating pump draws water from reservoirs with adjusting height capability.



Automatic Solar Water Pump Testing Facility

National Institute of Solar Energy (NISE) is involved in research, along with testing and certification of SPV water pumping systems as per MNRE's specifications and guidelines. It has a testing facility for SPV water pump systems, for performance evaluation and analysis, optimization of different types of pumps (AC as well as DC and submersible as well as surface pumps), of capacities ranging from 1 HP to 10 HP for different heads from 10 m to a maximum up to 100 m.



SPV module setup for pump testing at test bed

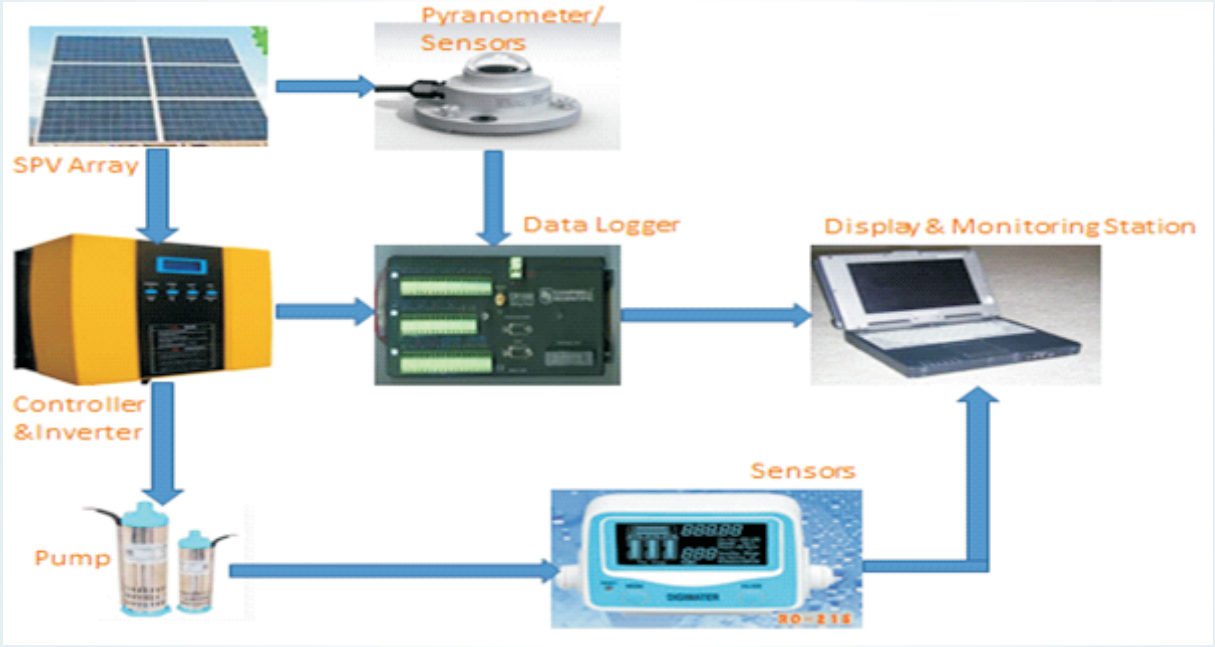


Solar Water Pump Testing Rig.

In the year 2015-16, NISE has tested 82 different types of SPV water pumping systems. Presently the facility is capable of testing four no's of SPV water pump samples at a time. Details of the tested samples are given under as:

S. No.	Capacity of Pump	Type: Surface/ Submersible	AC/DC	Head (in meters)	Total No. of Pumps tested
1	1 HP	Submersible	2 DC 3 DC 1 DC	30 60 90	6
2	2 HP	Submersible	3 DC 5 AC 2 AC 1 AC	30 10 20 30	11
3	3 HP	Surface and Submersible	4 AC 2 AC 25AC	20 30 50	31
4	5 HP	Submersible	5 AC 27AC 2 AC	20 50 70	34

A new automatic and up-graded SPV water pumping systems testing facility is under construction for increasing the number of samples to be tested with more accuracy which will also facilitate indoor testing and simulation of different testing conditions for different seasons. This facility is in the final stage of its completion



A Schematic diagram of Automatic Solar Water Pump test Set up

In view of the increase in demand of Solar Pumps in India, four more institutions have been identified and accredited as test centers by Ministry of New & Renewable Energy (MNRE) for testing of SPV water pumps as per ministry's specifications and guidelines. The four test centers are namely: TUV Rheinland India Pvt. Ltd. Bangalore, Scientific and Industrial Testing and Research Centre (SiTarc) Coimbatore, Central Power Research (CPRI) Bangalore, & UL India Pvt. Ltd. Bangalore. NISE shares technical knowledge with these institutes and provide training for taking up testing for SPV based water pumping systems.

Major Activities

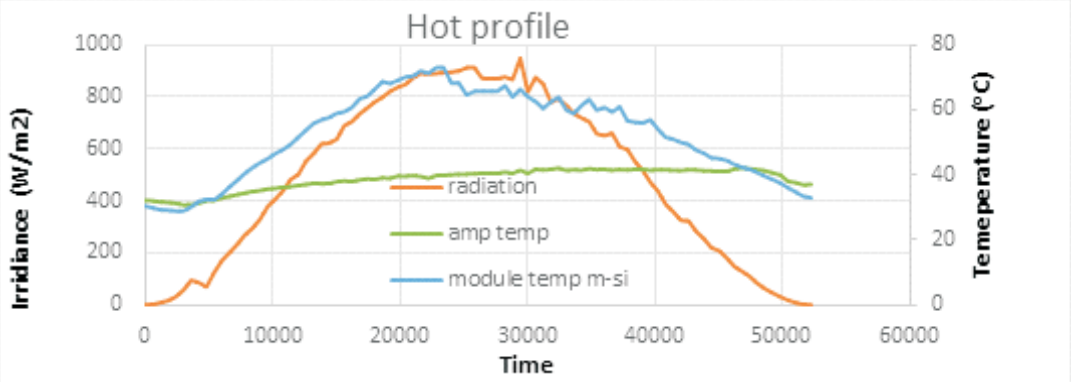
Major activities conducted by NISE are as follows:

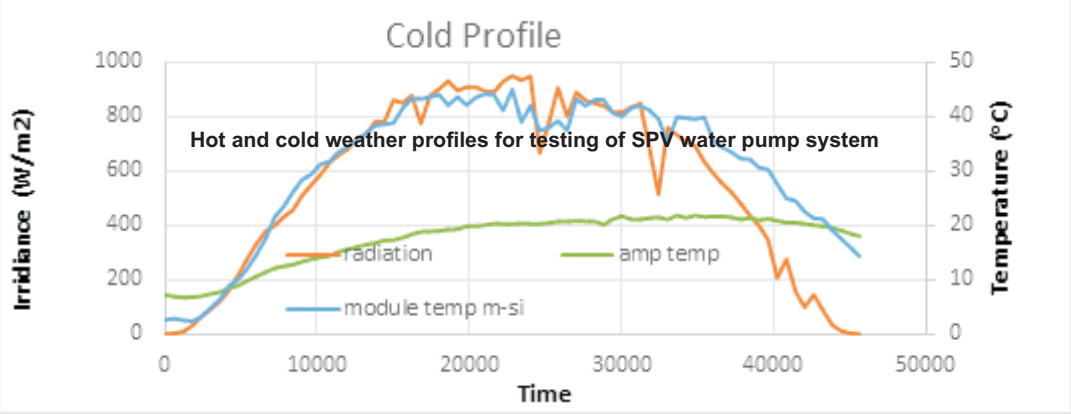
- Performance evaluation and study of different types of Controllers based on their MPPT operation.
- Study on suitable selection of different pumps based on head and optimum array sizing at different climatic zones of India
- Collaboration with renowned industries for technical advancement and knowledge sharing
- An automatic test facility for indoor as well as out- door testing of 8 nos of samples at a time with data logging and control mechanism is under final stage of development.

- Testing of different types of pumps of capacity from 1 HP to 10 HP in real outdoor conditions as per MNRE guidelines with testing time period of 7 days.

- Testing of different types of pumps of capacity from 1 HP to 10 HP with array simulator for different day profiles taking temperature and irradiance correction into account as per MNRE guidelines with testing time period of 2 days

- NISE has also conducted many training programs, site visits and demonstration sessions for creating awareness & knowledge sharing in SPV water pumping systems.





Hot and cold weather profiles for testing of SPV water pump system

Publications :

NISE has published/ sent for publication the following papers on SPV water pumping in various renowned national and international Journals/ Conferences:

1. Analysis of Temperature effect on Optimum Sizing of Solar Photovoltaic Water Pumping System, Renu, Birinchi Bora, Kamlesh Yadav, Manander Bangar, Arun Kumar, and O.S. Sastry, 42nd IEEE PVSC (accepted).

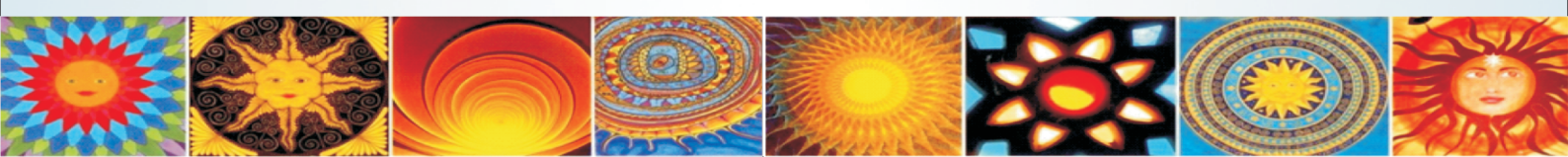
2. Performance Comparison of controllers for solar PV water pumping applications, Kamlesh Yadav, O.S. Sastry, Rashmi Singh, R. Wandhare, Renu, N. Sheth, A. Kumar, M. Kumar, B. Bora.

3. Design optimization of photovoltaic powered water pumping systems, Renu, Birinchi Bora, Manander Bangar, O.S.Sastry*, Supriya, Rashmi Singh

4. Performance evaluation of solar photovoltaic lighting and water pumping systems in India, O.S. Sastry, S. Agarwal, D. Adiraju, Rajesh Kumar and Bibek Bandopadhyay, 26th European Photovoltaic Solar Energy Conference and Exhibition.

5. Performance of Solar PV Water Pump System at Low Irradiance Condition, Manander Bangar, Birinchi Bora, O.S.Sastry*, Supriya, Rashmi Singh Renu. 32nd European Photovoltaic Solar Energy Conference and Exhibition

6. Optimum Array Sizing of Solar Photovoltaic Water Pumping System, Renu, Birinchi Bora, Manander Bangar, O.S. Sastry* B. Prasad, 32nd European Photovoltaic Solar Energy Conference and Exhibition



1.7. NEW TEST AND CHARACTERIZATION FACILITIES

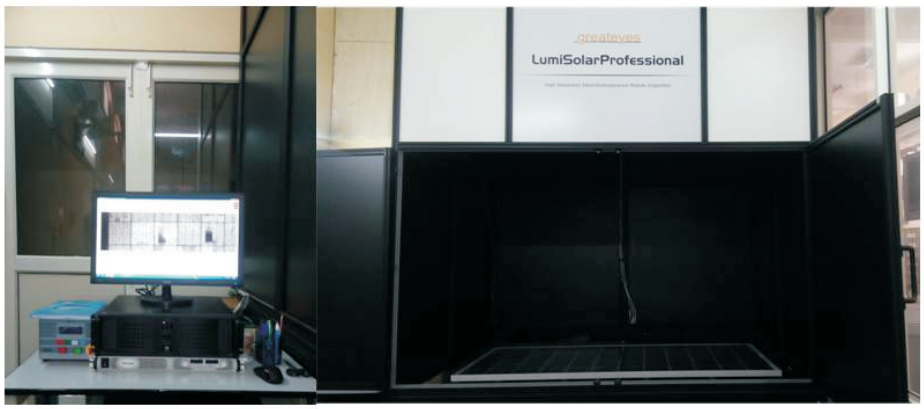
I. Electroluminescence (EL) test Facility for PV modules

Introduction

In the year 2015-16, Electroluminescence (EL) Test Facility for PV modules was established at the National Institute of Solar Energy. The EL test for PV modules is used off-line with manual operation (loading/unloading) for indoor measurement of PV Modules (framed/unframed) both before and after lamination.

Electroluminescence Test Set-up

The greateyes LumiSolar Professional BL 16Mpx (Bottom Load) System consists of high performance sensitive near-infrared CCD matrix cameras. The cameras are used in combination with a precision linear axis. Together they form a fast working EL imaging unit which offers both, market-leading sensitivity and high resolution, through the scanning process. The system software enabled image stitching/merging produces a seamless and clear EL image of the full module with a maximum size of 2 m x 2 m. The power supply is ensured by a programmable DC unit with a maximum voltage output of 150V and a maximum current output of 16A. The EL system has a computer interface which displays all defects to the operator as shown as below:



Module type: Mono and multi crystalline silicon (including Maxeon and HIT type of modules), thin film (CIGS, CdTe, a-Si based and other new technologies).

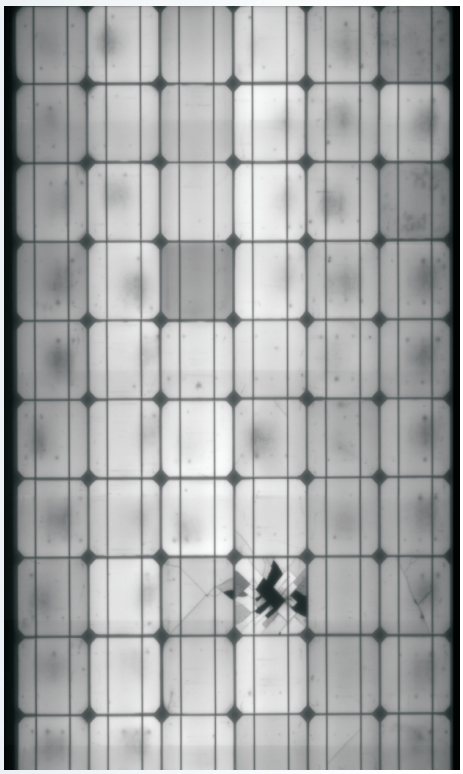
In general, Electroluminescence (EL) test is used to visualize different type of defects in solar cells and PV modules which are invisible to the human eyes. EL is emitted by a solar cell under forward bias and can be detected by a cooled silicon CCD camera in a dark condition. There is a proportional relationship between the intensity of the emitted EL signal and the applied bias level. The effects of resistive losses like series and shunt resistances are visible as areas of lower intensity in the EL image. These resistive areas can be detected by comparing EL images taken at different applied biases. These defects can have a significant effect on the performance and longevity of the module.

Inspection Capabilities:

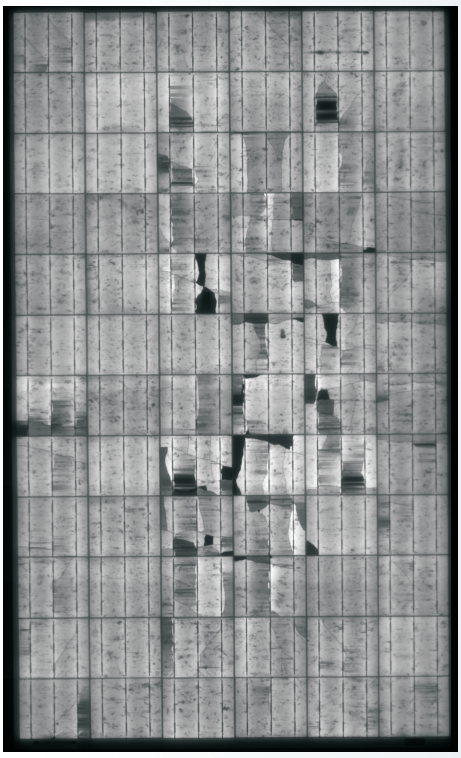
- Micro- and large cracks,
- Electrical shunts,
- Finger interruptions/ Printing defects,
- Soldering / Stringing Problems
- Series resistance
- Defects Inhomogeneities, Impurities.

Module type: Mono and multi crystalline silicon (including Maxeon and HIT type of modules), Thin film (CIGS, CdTe, a-Si based and other new technologies). Software enabled image stitching/merging produces a seamless and clear EL image of the full module with a maximum size of 2 m x 2 m.

A typical EL images performed LumiSolar Professional BL System with one camera:



(a) El Images of Mono-Si PV Module



(b) El Images Poly- Si PV Module

1.8 SOLAR DESIGN SIMULATION LAB

Introduction:

Solar design simulation lab is a new initiative of NISE for the development of project proposal, consultancy, training and other research and development purposes. This lab is a full-fledged functioning lab, comprising of audio visual facility for demonstration. There are different softwares available in this laboratory which can be used for the design of a PV power plant

List of available software at NISE

1. PVSYST V6.4.3, Switzerland
2. PVSOL Premium 7.5, Valentin software, Germany
3. TSOL Pro 5.5 Valentin software, Germany
4. SAM (System Advisor Model)- NREL USA
5. RET Screen, Canada
6. Archelios Pro, France

1. PVSYST V6.4.3, Switzerland

PVSyst V6.43 is a PC software package for the study, sizing and data analysis of complete PV systems. It deals with grid-connected, stand-alone, pumping and DC-grid (public transportation) PV systems, and includes extensive meteorological and PV systems components databases, as well as general solar energy tools. The system yield evaluations are performed very quickly in monthly values, using only a very few general system characteristics or parameters, without specifying actual system components. A rough estimation of the system cost is also available.

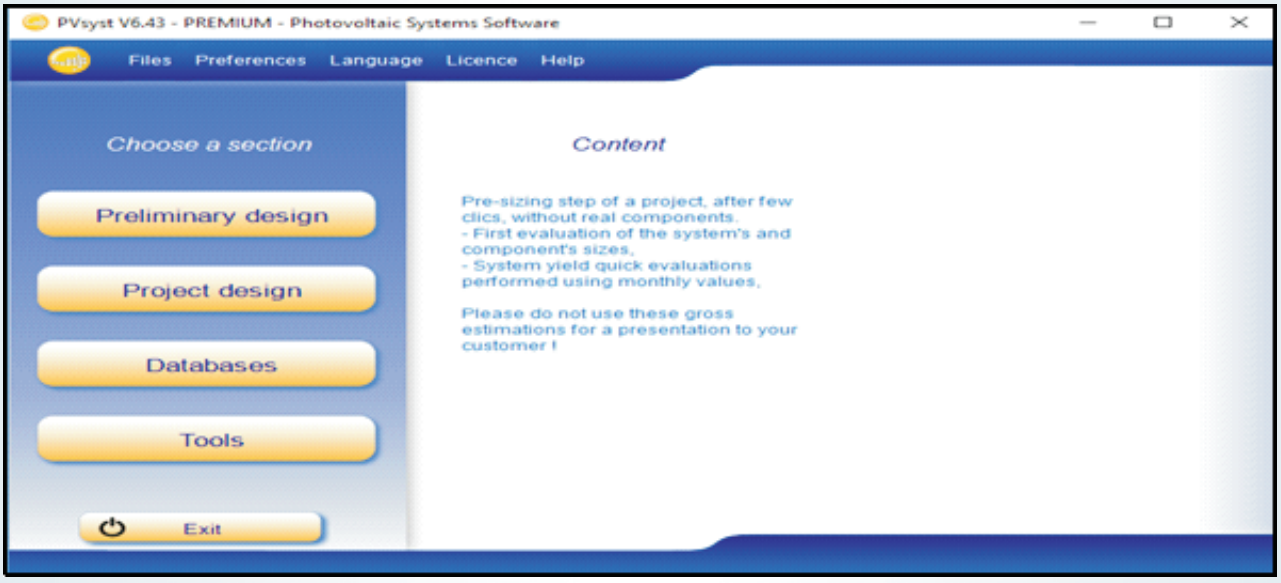


FIG: Designing options of PVSYST for solar power plant project

For stand-alone systems this tool allows to size the required PV power and battery capacity, given the load profile and the probability that the user will not be satisfied ("Loss of Load" LOL probability, or equivalently the desired "solar fraction")

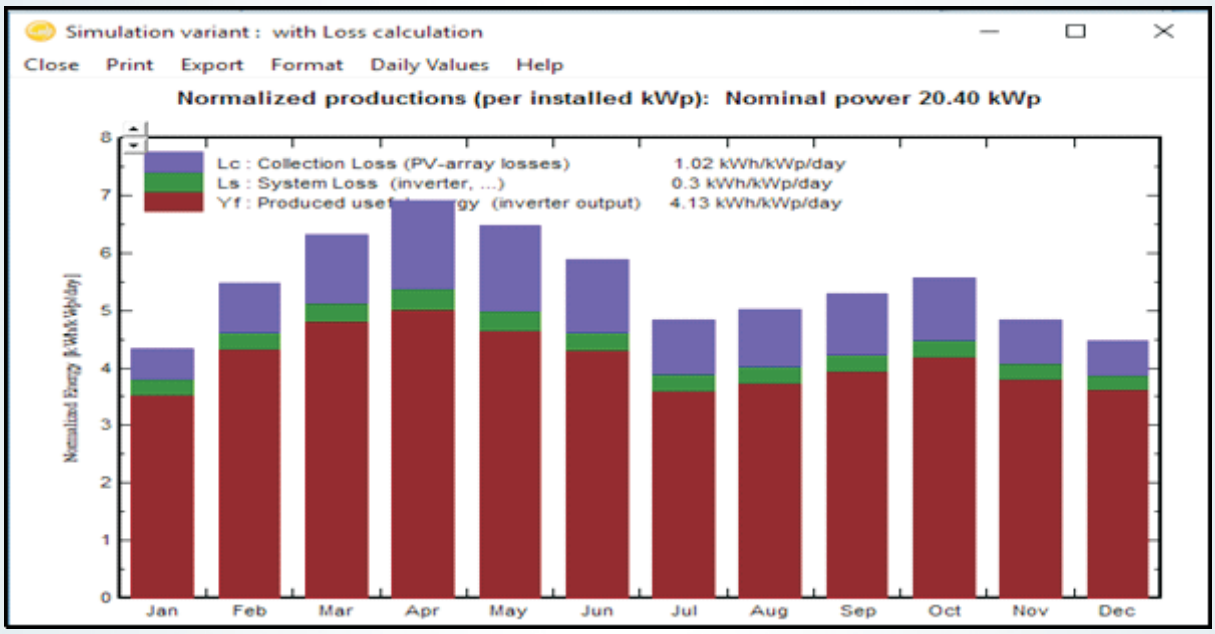


FIG: Normalized energy yield for different month

For pumping systems, with given water requirements and head, and specifying some general technical options, this tool can evaluate the size of pump and PV array size needed. As for stand-alone systems, this sizing can be performed according to a specified probability that the water needs are not met over the year.

2. PVSOL Premium 7.5, Valentin software, Germany

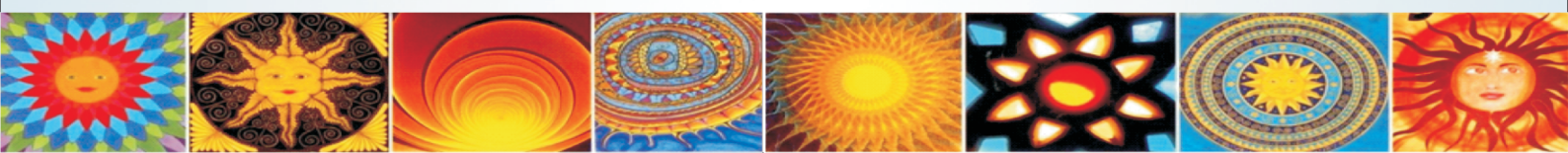
This software has some advantages as given below:

Easy configuration:

- Automatic determination of the best inverter configuration
- Manual adaptation of the configuration sophisticatedly supported

Entering the PV module areas in various ways

- Determination of the number of modules and visualization of the module surface using a photo of the house.
- Automatic module mounting on any roof type in a graphical 2D roof view
- Simple parameterization of the module surface



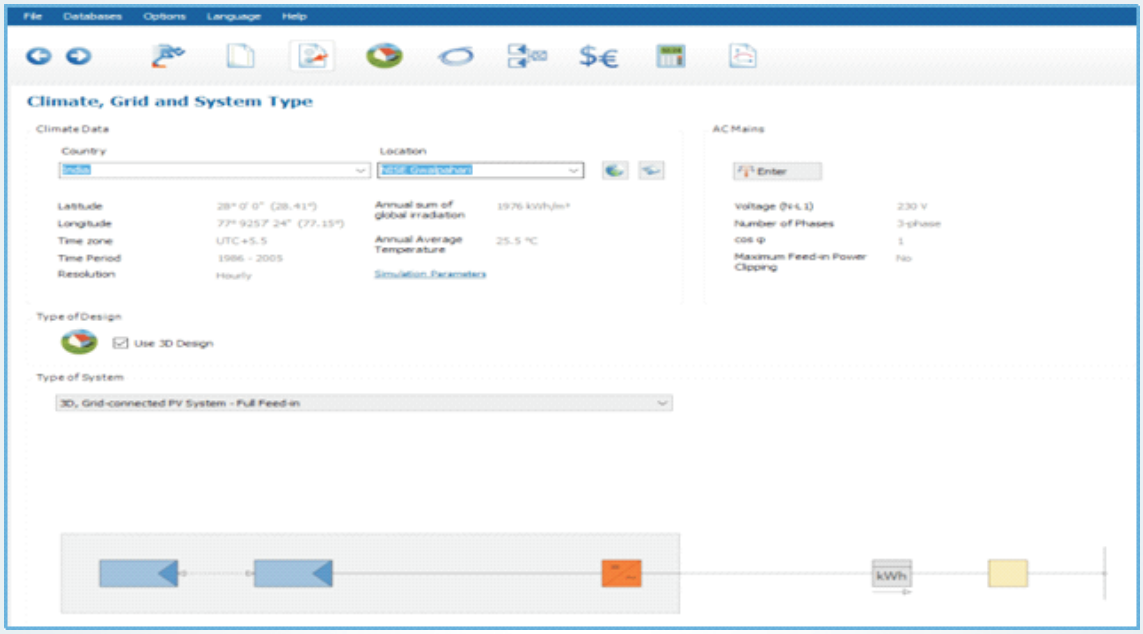


FIG: Grid interactive solar power plant designing

Optimal evaluation and presentation of results:

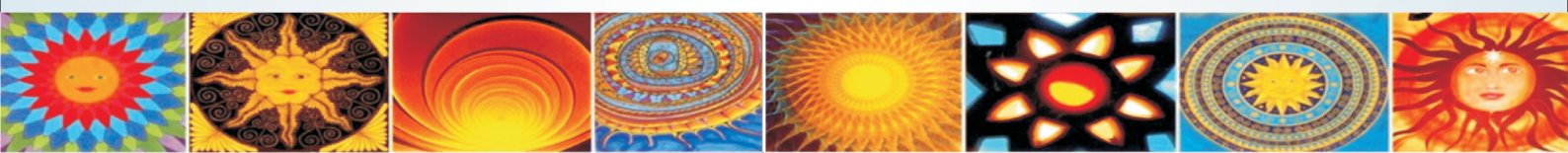
- Hourly yield simulation of grid-connected PV systems
- Detailed economic forecast including main parameters like yield payback time
- Configurable project documentation printout including .pdf export

Always up to date

- Databases are regularly updated by the manufacturers (PV modules inverters, battery inverters)
- Releases available regularly via program Internet update

Optimal user support

- The clear structure of the input parameters allows the rapid completion of the project. Detailed settings are possible in sub-dialogs.
- Any dimensioning errors are avoided by entry verification
- Extensive help, printable .pdf manual
- Easy selections of products (batteries, PV modules, inverters, battery inverters) are possible via favorite



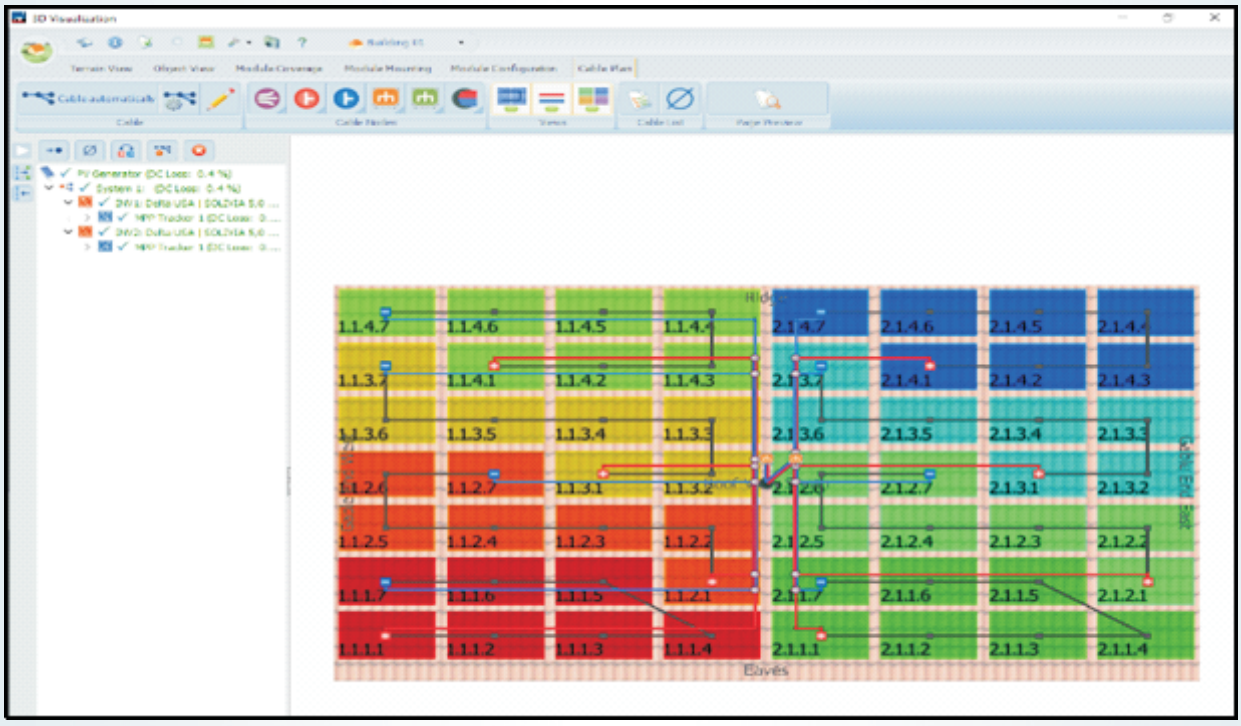


FIG: Array configuration of PVSOL designing

- Planning of PV systems with consumption, net metering and battery storage systems
- Calculation of AC losses DC losses and string losses
- Climate data selection using zip code or map, or your own climate data

3. TSOL Pro 5.5 Valentin software, Germany

Overview

- Simulation of solar thermal systems for DHW supply and space heating over any period of time up to one year
- Design (optimization of collector area and storage tank volume) to reach specific targets
- Influence of partial shading by the horizon and other objects (buildings, trees etc.)
- Graphic and tabular entry of shade values
- Extensive component database

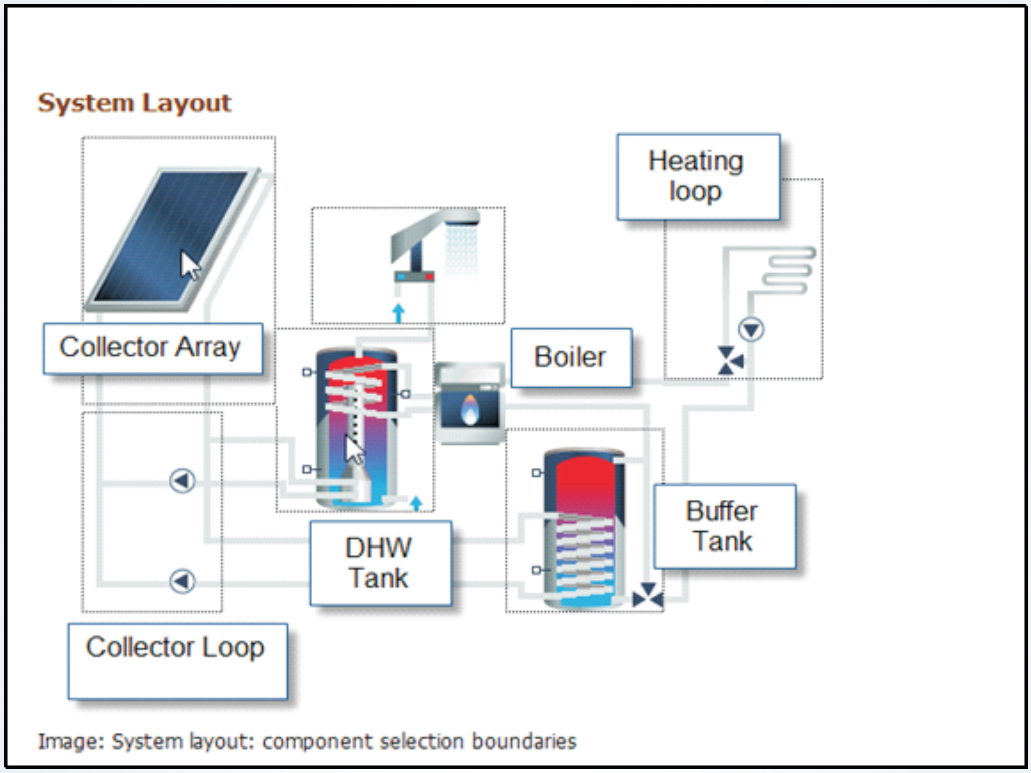


FIG: TSOL Pro 5.5 designing for different solar thermal application

- Roof coverage with Photo Plan
- Domestic hot water consumption profiles included in calculations
- Both radiator and underfloor heating possible
- Convenient comparison of several systems with parallel variant editing within a project
- Balancing of energy, pollutant emissions and costs
- Calculation of standard evaluation parameters for solar thermal systems such as system efficiency, solar fraction etc.
- Detailed presentation of results in reports and visuals
- Financial Analysis of a system following simulation over a one-year period

System Configuration

- Can be select from common system configurations.
- Outdoor and indoor pools can be integrated within the solar cycle.
- Large-scale systems are integrated.

- System components, e.g. collectors, boilers, storage tanks, and also consumption profiles are loaded from the databases.

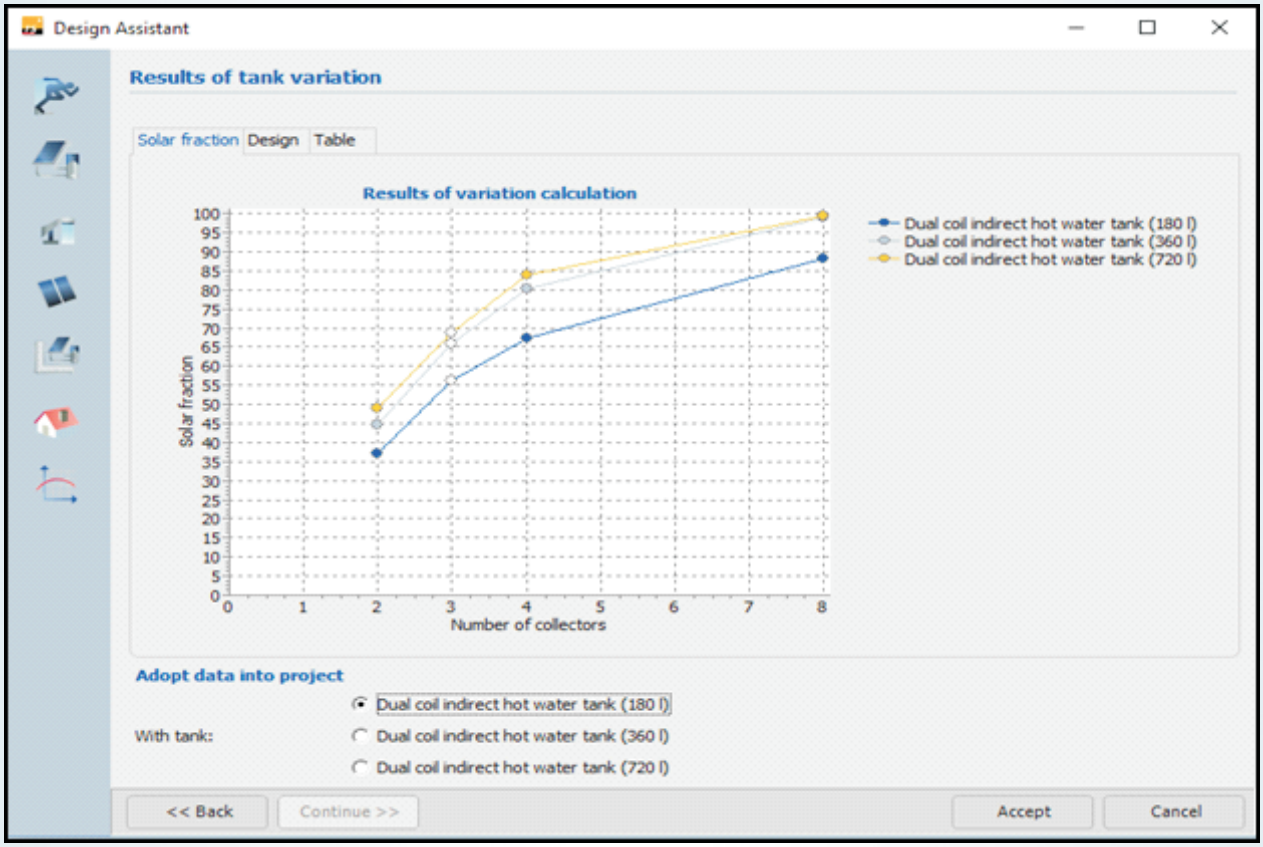


FIG 6: TSOL Pro 5.5 solar thermal designing for different application stimulation result

4. SAM (System Advisor Model) - NREL USA

Introduction

The System Advisor Model (SAM) is a performance and financial model designed to facilitate decision making for people involved in the renewable energy industry:

- Project managers and engineers
- Policy analysts
- Technology developers
- Researchers

SAM Models and Databases

SAM represents the cost and performance of renewable energy projects using computer models developed at NREL, Sandia National Laboratories, the University of Wisconsin, and other organizations. Each performance model represents a part of the system, and each financial model represents a project's financial

Simulation results

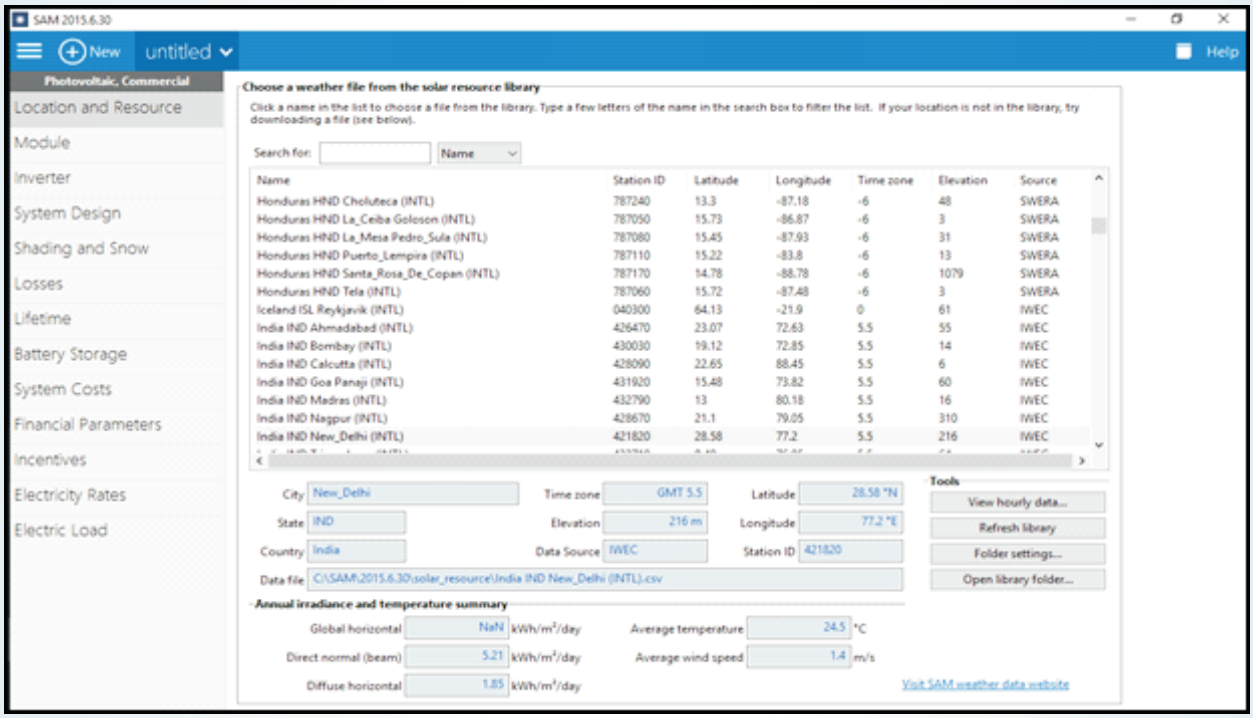


FIG 7: SAM designing of power plant with financial

SAM displays simulation results in tables and graphs, ranging from the metrics table displaying the project's net present value, first year annual production, and other single-value metrics, to the detailed annual cash flow and hourly performance data that can be viewed in tabular or graphical form.

5. RET Screen, Canada

The RET Screen International Clean Energy Decision Support Centre seeks to build the capacity of planners, decision-makers and industry to implement renewable energy, cogeneration and energy efficiency projects. This objective is achieved by developing decision-making Tools (i.e. RET Screen Software) that reduce the cost of pre-feasibility studies; disseminating knowledge to help people make better decisions; and by training people to better analyses the technical and financial viability of possible projects.



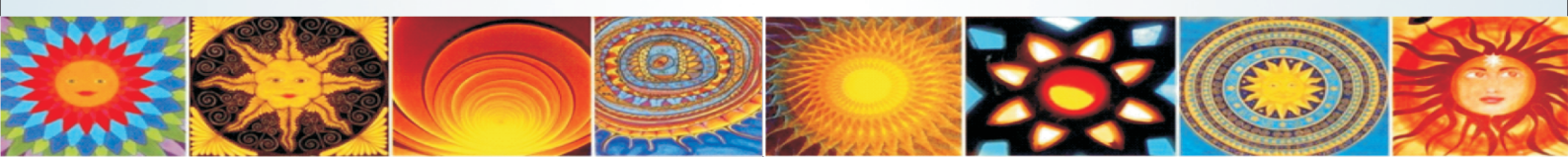
FIG 8: RET Screen designing for technical and financial project

6. Archelios Pro, France

Archelios Pro is an online/ offline application design, simulation and economic analysis of photovoltaic projects for professionals. Archelios Pro offers all the features and databases required for the design of any type of photovoltaic system (on roof, ground, grid injection, isolated sites or self-consumption). Simple to use, Archelios Pro provides a simulation project in 3D. Real tool for decision, ArcheliosPro allows complete analysis of the profitability of the installation. With multi project comparison functions, the designer can define the best possible configuration for optimal installation.

Main features

- Access to global coverage of weather stations for sunshine data
- 3D modelling of the system and each component with the plug-in Sketch Up (precise calculation of shadows by modelling the curves I-V for each module and string)
- 3D simulation of the pattern layout and wiring.
- Online application is easy to use, easy to access, including smartphones, with a clear and detailed graphic display.
- Easy comparison between projects (choice of materials or different wiring) for optimum profitability
- Calculation of production and economic profitability with consideration of CGA (updated overall cost) in €/kWh
- Accurate and detailed calculations for a real estimate of the project.
- Innovative tool for estimating self-consumption (edition of daily power consumption profiles) and energy storage.



Consultancy and training programs :

This simulation lab is dealing with consultancy of different projects and training of people from different counterpart, industries, students etc. In this past year this lab was involved in the training of senior engineers and managers from SJVN, Fishery department Andhra Pradesh and international trainees through ITEC.



FIG: Some of the trainee participated in one of the training program

Publication:

[1] Yogesh Kumar Singh, Birinchi Bora, Ramayan Singh, Suprava Chakraborty, O. S. Sastry, Rashmi Singh, Supriya Rai, Kamlesh Yadav, Performance analysis of different Thin Film Module Technology in Indian Climatic Condition, 32nd European Photovoltaic Solar Energy Conference and Exhibition

Chapter - 2

Solar Thermal & Resource Assessment Energy Division

Solar Thermal Division of National Institute of Solar Energy (NISE) has undertaken various research projects in collaboration with national/ International research institutions/ organizations and industries. The following major research and development facilities have been installed in the NISE campus:

1. Ongoing R & D projects

- 1 MWe Solar Thermal Power Plant
- Modular Central Receiver Concentrated Solar Power Plant for Decentralized PowerGeneration
- Solar Cooling Facility
- Solar Sterling Engine
- Solar Distillation System

2. In house Research and Development activities

3. Solar Thermal Testing Facilities for Concentrated Solar Thermal and Solar Water heating Systems

4. Solar Resource Measurement and Assessment Facility

2.1 Ongoing R & D projects

(a) 1 MWe Solar Thermal Power Plant

A grid-interactive solar thermal power plant, with a capacity of 1 MWe, has been designed developed and commissioned at National Institute of Solar Energy (NISE). The unique feature of the plant is the integration of two different solar fields viz. parabolic trough collectors and linear Fresnel reflectors, without a fossil fuel backup. The plant intends to combine the advantages of synthetic oil based Parabolic Trough Collector (PTC) field for high efficiency and direct steam generation (DSG) of linear Fresnel reflector (LFR) field to lower down cost of generation. As per the design specification, operating pressure is 40 bar (250oC) and temperature is 350oC (superheated) steam to run a steam turbine, based on the Rankine cycle principle. The Solar thermal power plant is shown in Fig 2.1







Fig. 2.1: 1 MW Solar Thermal Power Plant

The linear Fresnel reflector solar field has been designed to generate saturated steam at 40 bar and 250oC. The parabolic trough field has been designed to raise the Thermic-fluid temperature to 390oC, for parallel steam generation. However, steam generated from both the fields is superheated from parabolic trough field

(b) Modular Central Receiver Concentrated Solar Power Plant for Decentralized Power Generation

A Project was undertaken for development of modular central receiver concentrated solar power plant for decentralized power generation in collaboration with Sun Borne Energy Technology Pvt. Ltd. Under the project, designing of heliostat along with its numerical analysis and control system, testing and optimization of heliostat have been completed including design, component specifications, assembly and erection procedures, and controls. In house mirror gluing and curving process was developed which has been documented, tested, and finalized. Canting technique has been developed and 12 Heliostats have been canted and erected. Steel tower of height +32.5 m has been completed with Jib crane at top. Electrical wiring and control work for complete solar field and prototype receiver have been completed. Selection of volumetric absorber materials based on experimental investigation carried out at ETH Zurich and installation of the prototype receiver with heat exchanger along with necessary instrumentation and controls system have been completed. Testing of 50 kWth (Designed) prototype air receiver has been conducted for finalization of design of receiver. A parametric study has been performed to analyze the Thermal Storage behavior. Based on the study a Numerical Model for thermal storage has been prepared and validated against

important design parameters. The prototype thermal storage experiment has been carried out at University of South Florida, USA

(c) Solar Cooling

Under an MNRE sanctioned R & D project, NISE in collaboration with M/s Thermax Ltd. Pune has taken up a project on Design, Development and Demonstration of the following three solar cooling systems in different configurations using solar thermal energy:

100 kW High Efficiency Absorption Prototype System

The system consists of a high efficiency three stage Vapour Absorption Machine (VAM) based on LiBr-H2O cycle with Coefficient of Performance (COP) of 1.7, at suitable medium temperature of solar concentrating collectors with appropriate storage system (Fig 2.2). The 288 m2 parabolic trough collectors (PTC) provide 210 0C temperature pressurized water. This heat is used in VAM to generate 7 0C chilled water which, in turn, is circulated through the Fan Coil Unit installed in various rooms to be cooled. Besides the triple effect unit, the system has indigenously built medium temperature parabolic troughs for the collection of solar energy. System has special arrangement of storage of heat and cold using Phase Change Materials (PCM).



Fig. 2.2: 100 kW High Efficiency Triple Effect Vapor Absorption System

In winter, the solar heated water, instead of pushing through the VAM, is circulated through the Fan Coil Unit to provide heating.

15 kW Absorption Prototype System with air cooling

A 15 kW LiBr-water double effect absorption prototype system with air cooling was installed and commissioned in December 2013 at the NISE campus (Fig. 2.3). This unit uses hot water at around 170 0C as heat source. Indigenously developed Parabolic Trough Solar Collectors (PTC) with a total collector area of 96 m2 are used to provide the required pressurized hot water to the Vapor Absorption Machine. This pressurized hot water in VAM is used to generate chilled water at 9 0C which is circulated through the Fan Coil Unit installed in various rooms to be cooled.



Fig. 2.3: 15 kW Solar Absorption Refrigeration System (Air Cooled)

5 kW Adsorption Prototype System

A 5 kW prototype system based on water cooled adsorption cycle was installed in December 2013 at the NISE campus (Fig 2.4). The adsorbents are specially synthesized to suite the tropical climatic conditions. The objectives are development of cost effective high efficiency cooling engine and indigenous components for vapor adsorption machine, and non-imaginary solar collectors system have been designed to harness sun's energy in an effective manner to provide temperatures up to 120 0C with improved efficiency including integration of the components to achieve consistent performance of the system. Compound Parabolic Concentrator (CPC), an enhanced version of Evacuated Tube Collectors is used to provide the required heat to the Adsorption Machine. The total collector area is 61 m2. The system provides 5 kW of air conditioning to an office cabin with chilled water at 9 0C circulated through a fan coil unit.



Fig. 2.4: 5 kW Adsorption Refrigeration system

(d) 50 kW Solar-Biomass Hybrid Cold Storage cum Power Generation System for Rural Electrification

NISE in collaboration with M/s Thermax Pvt. Ltd., Pune and The Energy and Resources Institute (TERI), New Delhi has developed and installed a 50 kW solar-biomass hybrid cold storage cum power generation system for rural electrification at the NISE campus (Fig. 2.5). The system consists of a 50 kW biomass gasifier including gas cleaning and cooling system, 50 kW 100% producer gas engine, heat recovery unit, 15 kW ammonia+water VAM, 4 Scheffler Dishes with 16 m2 area for each and cold storage room of 20 metric tons capacity.

The 50 kW biomass gasifier system provides electricity and the waste heat of the engine (exhaust) is used as the main source of energy for the cold storage. During the day time, when the sunshine is available the Scheffler Dishes along with engine exhaust provide heat to the system and in the evening as well as when there is no sunlight, the gasifier is run to meet the evening electricity load and the cold storage will operate only on engine exhaust. In case, no sunshine is available and engine exhaust is also not sufficient, provision has been made for firing of producer gas in Heat Recovery System to meet balance heat requirement for running the cold storage



Fig. 2.5: Solar Biomass Hybrid storage system

(e) Solar Stirling Engine

Three 3 kWe Stirling engines were installed at the NISE Campus in collaboration with ONGC Research Centre for performance evaluation and assessing its suitability in Indian conditions (Fig 2.6). Each system consists of Parabolic Dish concentrator, piston free Stirling engine cum reciprocating generator mounted on a moving receiver. Helium is used as the working fluid. GPS based 2 axis tracking mechanism has been used for tracking of parabolic dish. As a result, system is facing 'zero cosine losses'. System efficiency is 24 % from sun to electricity at 850 W/m2 DNI and 25 0C ambient temperature.



Fig. 2.6: Solar stirling engine at NISE

(f) Solar Water Distillation System

A solar water desalination system was installed at the NISE campus under a collaborative project with an Australian company, FCUBED Pvt. Ltd to evaluate performance in different Indian climatic conditions (Fig. 2.7). The system consists of 10 panels of specially designed solar collector of 3 m2 area each. A provision of SPV panel and DC pump has also been provided for lifting of water from storage tank to solar collector. Performance evaluation study has been carried out and study reveals that it can produce pure clean drinking water up to 150 litres per day from any type of water. This system is the one of the most efficient and cost effective compared to other water distillation systems.

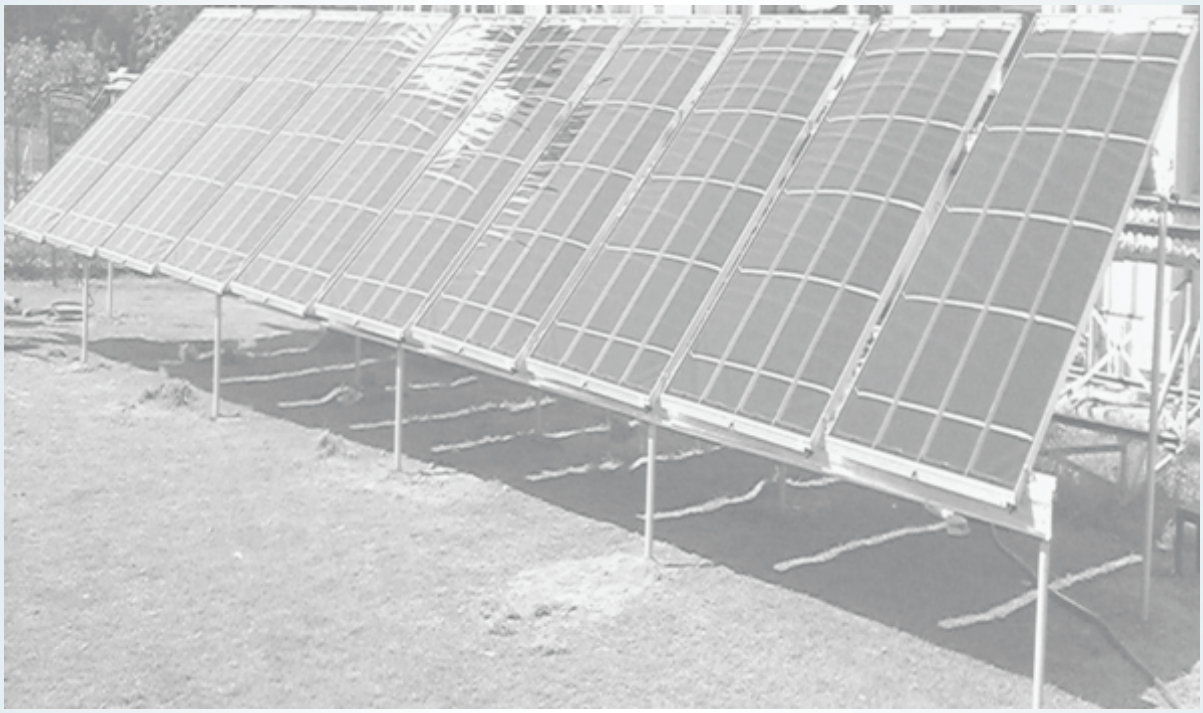


Fig. 2.7: Experimental setup of Flat Plate type Solar Water Distillation system

2.1.2 Major Activities in 2015-16.

- The data collection and analysis has been taken up for 1 MW solar thermal power plant.
- In-house maintenance and necessary repair work of the facilities of 1 MW solar thermal power plant were carried out
- The process of handing over of the Modular Central Receiver Concentrated Solar Power Plant for Decentralized Power Generation was initiated and the facility will be used for R&D activities
- Data procurement from various solar cooling system is under process. This will facilitate R&D activities to understand the long-term performance and profiling of various configuration of different solar collectors for cooling applications
- A techno economic model has been developed for designing of solar cooling for various location in India and PhD project has also been realized through this project.

- Maintenance and service/ repair of solar cooling facility is jointly undertaken by NISE and Thermax Pvt. Ltd.
- The process of handing over of the 50 kW Solar-Biomass Hybrid Cold Storage cum Power Generation System for Rural Electrification was initiated. The performance evaluation of the Scheffler dishes are being undertaken in this project.
- The maintenance activity of Stirling Engine was carried out jointly by NISE and ONGC and the operational data of the system was logged and analysed
- Data collection for performance evaluation of inclined plate type solar distillation is underway
- Various M.Tech and B.Tech students completed their internships on solar thermal projects
- A study has been undertaken for performance evaluation and optimization of the PTC technologies.
- Study has been undertaken to optimize the system performance during different radiation and ambient conditions.
- The study was carried out to simulate performance of system in different parts of the country.
- Visit of various dignitaries, stakeholder and in-house trained participant were organized for knowledge enhancement in various solar thermal projects

2.2 In house Research and Development activities

NISE has carried out research, design & development in following areas of solar thermal systems

2.2.1 Design, development and fabrication of Multi effect humidification and dehumidification distillation systems with heat storage using phase change material for operation during non-sunshine hours

The prototype Multi effect humidification and dehumidification distillation systems with heat storage using phase change material was designed and fabricated in the Solar Thermal R & D laboratory. The heat collection part has been designed to continuously provide hot water to the evaporation unit of the distillation system and heat storage for continuous production of drinking water in intermittency of day / night cycles and also in reduced radiation periods (winter, cloudy days, and short transients). The distillation chamber consists of humidifier & dehumidifier towers. The circulation of air in the two towers is being maintained by natural convection. The developed model is useful in the estimation of the distillation plant output. It has optimized various components of the system viz. solar water heater, heat exchanger, humidification chamber, condensation chamber and the important one is heat storage material (aluminum, wax & gypsum and/ or porous type material for water absorption).

The design work has been completed as per the availability of locally material, the design fabrication expertise and also functioning of the system without any conventional power. The system is demonstrated into three parts; (a) Storage tank (b) distillation chamber (c) Heat storage in the evaporation chamber, which collects heat from spraying of hot water at desired temperature range. The collection section consists of the collector and storage designed for continuous feeding of the hot water to the distillation chamber as shown in Fig. 2.8

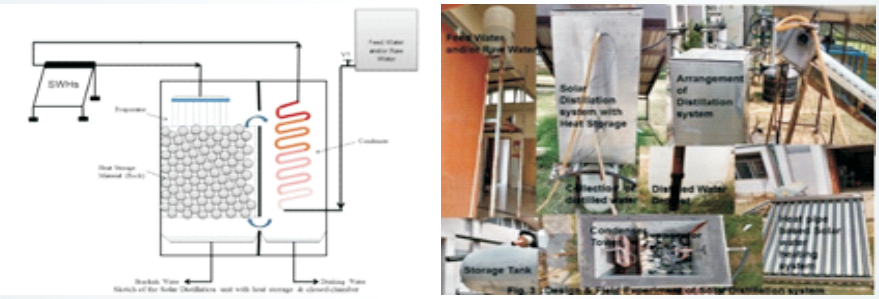


Fig. 2.8: Multi effect humidification and dehumidification distillation systems

In this design, heat pipe based solar collector/ concentric tube collector has been used for heating water up to 70-750C as per flow rate of spraying water. A 120 liters capacity storage tank provides continuous hot water to the distillation evaporation chamber. The tank is fabricated of a good quality stainless steel (SS 316) and SS304-2B (22SWG) and is properly insulated with high density injected PUF (Poly Urethane Foam) insulation (50 mm). The insulation thickness between inner and outer tanks ensures maximum heat retention for a maximum of 72 hours. The storage tank has a special provision to supply the hot water for a period of 5-6 hours to the distillation chamber at night.

The distillation chamber is divided into humidifier and condensation chambers. The humidifier chamber is designed in such a way that the evaporation of water is taken to the condensation chamber. Two types of heat storage (Phase Change Material (PCM); paraffin type wax) material is taken to store the latent heat. The shape of the storage PCM is spherical type with 2-4 mm thickness of cascade and/or gypsum type material layer is used in the outer of the plastic and/or aluminum shape. The PCM collects heat from the spraying hot water at 72-80oC and gives the latent heat at the desired temperature for continuous production of drinking water in intermittency of day/ night cycles. The feed water is preheated in the condenser tower through copper tube and supplied to the heat pipe/ concentric tube collector. Preheated feed water gets heated up and is supplied to the storage tank. The hot water is again supplied to the top of the humidifier chamber at a desired mass flow rate. The sprayed hot water flows through the PCM material in the humidifier and heats the PCM. The small amount of humidified hot air from humidifier is drifted towards the condensation chamber by natural convection. Then the air gets partially dehumidified in the condensation chamber and goes back to the humidifier. The study is being carried out to simulate the performance of system in different heat temperatures.

2.2.2 Design, development and fabrication of a high efficiency desalination system using multi condensation.

A Lab Scale high efficiency Desalination system using multi condensation effects was designed and fabricated at Solar Thermal R&D Laboratory (Fig. 2.9). The system has a capacity of producing two liters of water per day using the concept of evaporation of raw water and condensation of steam to and from the humid air that is circulating through the system. In the evaporator the hot water at a temperature of 80-85 ºC is being heated through conventional heater and distributed onto vertically hanging fleece sheets and is slowly trickling downwards. The humid air flows in a circuit driven by natural convection between condenser and evaporator which is located inside the thermally insulated box. When the air comes in contact with the hot saline water in the evaporator a certain quantity of water vapor is extracted by the air. Part of the vapor mixed with air could be recovered as condensate by bringing the humid air in contact with the condenser in which saline feed water is preheated by the latent heat of condensation. The air moves in counter-current flow to the brine through the evaporator and becomes saturated with humidity. Here the

condenser. The distillate water comes down the surfaces and trickles down ot a collecting basin.



Fig. 2.9: Experimental setup of Multi effect desalination system

After successful completion of the prototype system, it is proposed to develop a large scale advanced multi-effect desalination system using multi condenser at NISE

2.2.3 Design and Simulation of hybrid solar-biomass power plant with combined power, cooling, and desalination in poly generation process.

A study has been carried out on the design and simulation of a hybrid solar-biomass power plant with combined power, cooling and desalination in polygeneration processing software in different parts of the country

2.2.4 *Design,* development and fabrication of low cost portable solar distillation systems.

NISE has developed a low cost Portable Solar Water Distillation system (PSWDs) for domestic applications in the remote areas such as villages, defence establishments in forward areas, hilly areas of Himalayan region, islands and coastal areas. The system is a simple modular design, solar distillation panel cum tank and handles cum stand, which can be installed in balconies, terraces, roofs, gardens and requires a very small shadow free area. The PSWDs has been designed in such a manner that it can easily be carried in hand or on back of a man. Its main advantage lies in easy construction and simplicity of operation and maintenance. Portable type solar distillation systems have an edge over other distillation systems as there is no installation cost, no manufacturing base, no spare parts & no trained manpower required. The PSWD system is designed with a glazed area of 0.25 m2, weighs about 6 kg and has a thin black cloth of 0.2 mm for absorbing the input water. The front glazing is of polycarbonate thin sheet (0.18 mm). Plastics and Stainless steel sheet material has been used for the modular/Panel whereas the insulation used EPS thermocol of 25mm. (Fig. 2.10 and 2.11) However, all the components of the system that come in contact with water, should be corrosion resistant. The PSWD system was kept at an angle of 280 inclination at NISE so that

maximum radiation reaches the polycarbonate sheet and is absorbed, thus make dripping water rundown on the black cloth. The inlet raw water is stored at the top of the system and outlets of distilled water and hot brackish water are at the bottom of the system. The feed water comes from the tank and falls at the black cloth, kept inside the system. A layer of water is created all over the cloth. Solar energy falling on the system heats up the water soaked by the black cloth and gets evaporated at 65-700C. Then the water vapours get condensed as it touch the cool (ambient temperature) polycarbonate sheet. The condensed water flows down and is taken out from the side of the cavity and collected in a tank. The rest of the feed water, which is hot brackish water flows into bottom collection tank. It is observed that, the drinking water rate achieved from the PSWD of 0.167 liters/hour per 0.25 m2 at global radiation 1.55 kWh/0.25 m2 and at ambient temperature of 38^{0}C. The study is being carried out to simulate the performance of system at different heat temperatures.

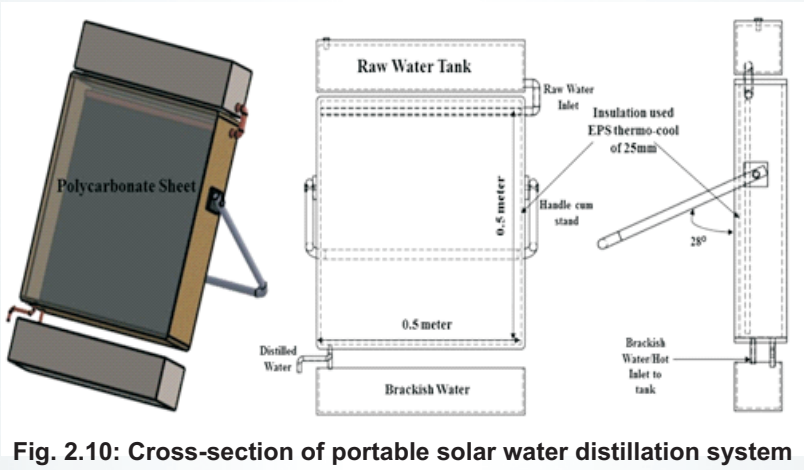


Fig. 2.10: Cross-section of portable solar water distillation system



Fig. 2.11: Experimental setup of portable solar water distillation system

2.3 Solar Thermal Testing Facilities for Concentrated Solar Thermal and Solar Water heating Systems

2.3.1 Hot water based solar thermal test facilities for CSTs

NISE has created facility for characterization and testing of all types of concentrating solar technologies. Concentrating solar technologies across the country can prove to be a foundation for emerging solar thermal and related applications in the booming solar energy industry. In the year 2015-16, NISE has tested 4 m2

energy industry. In the year 2015-16, NISE has tested 4 m^2 based paraboloid dish system as shown in **figure 2.12** and given the certificate to the manufacturer. The dish has automatic tracking system according to sun inclination using microprocessor based electronic control circuit.

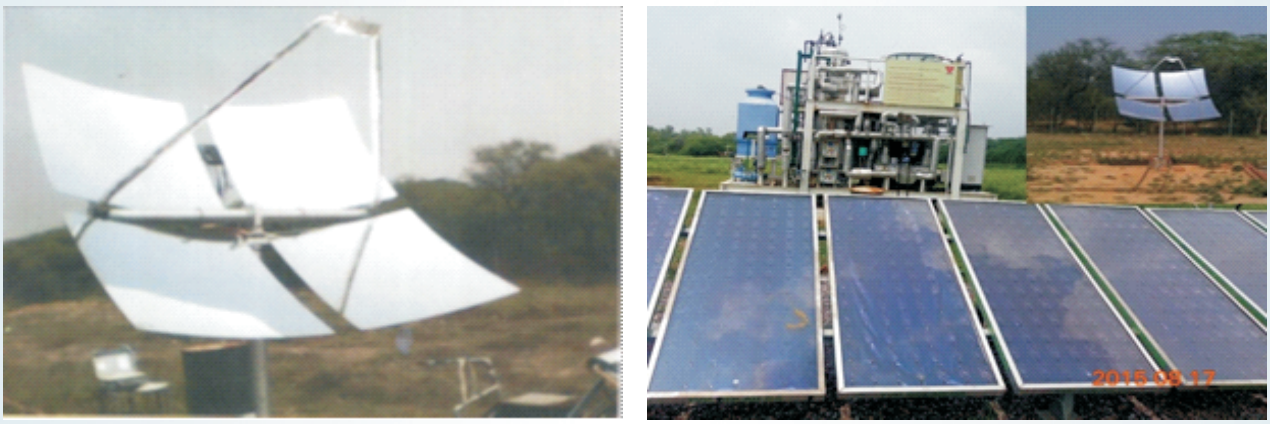


Fig. 2.12: Testing of solar dish for high temperatures at NISE

The specifications of the solar dish system are given in Tables 1, 2 & 3.

Table 1: System Specifications

System specification	
Weight	90 kg
Dimension of collector unit	2.1*2.5*1.8(mm)
Gross area	4.2 m^2
Working Fluid	Pressurized hot water
Tracking	Dual axis Auto tracking with stepper motors

Table 2: Reflector Specifications

Reflector specifications	
Type of Reflector	Solar Grade mirror (Curved)
No of mirrors	4
Area of one mirror	1.05 m^2
Thickness of Reflector (mirror)	4.38 mm
Reflectivity	92.4%

Table 3: Absorber/ Receiver Specifications

Absorber/ Receiver specification	
Type of receiver	Honey comb Fins type receiver
Material	Copper plate with selective coating in front
Dimension	75 cm^2
Surface treatment	Pyromark 1200 Flat Black
Absorptance	98.3%

The assumptions taken for the testing of the system are given in the Tabe 4.

Table 4: Test Condition parameters

Test conditions	
The test was conducted under Steady state condition	
DNI Range	400-600 W/m^2
Flow rage	220 to 600 Kg/h
Temperature range	30 to 120° c

The results show that, the optical efficiency of the system achieved is up to 79.62 % and the convection heat losses (W/m2K) and radiation heat losses coefficient are given in following Table 5. The characteristics curve is shown in Fig. 2.13. It is seen that, the efficiency decreases with increase in mean temperature of the collector.

Table 5: Test Results Parameters

Test Results	
η=0.7962-0.253x-0.49x^2	
Optical efficiency	79.62%
Convection heat loss coefficient a1(W/m^2 K)	0.253
Radiation heat loss coefficient a2(W/m^2 K)	0.001

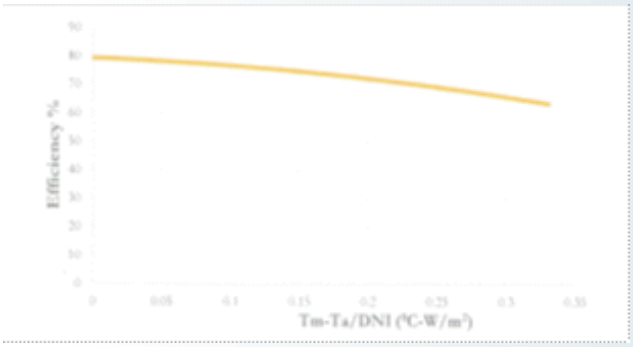


Fig. 2.13: Characteristics curve

2.3.2 Thermic fluid based test set up for CSTs

In 2012, NISE established a thermic fluid based CST test facility to test the thermal performance as part of the project entitled "Development of a Megawatt-scale Solar Thermal Power Testing, Simulation and Research Facility" in collaboration with IIT Bombay (Fig. 2.14). This test facility is capable of testing all the CSTs using thermic fluid as heat transfer fluid with temperature up to 4000C. The heat transfer fluid for testing is Therminol VP-1. The CSTs have been tested using heat transfer oil at various temperatures up to 4000C at oil flow rates from 5-7 kg/s, and pressures up to 10-15 bar. The test facility offers the characterization of CSTs to provide the opportunity for design improvements and selection of concentrators for various applications.



Fig. 2.14: Thermic fluid based Test Set-up for CSTs at NISE

2.3.3 Solar Thermal Test Facility as per BIS and MNRE Standards

A Test Rig for testing of Flat Plate Collector (FPC) system as per Bureau of Indian Standards (BIS) and Evacuated Tubular Collector (ETC), solar cooker (i.e. box type and paraboloid solar cooker) has been established at outdoor test bed at the NISE campus. During the year 2015-16, two solar water heating systems were tested

2.3.4 Testing of solar thermal system components

NISE has also created an indoor test facility for;

- Receiver heat loss characterization in Indoor testing condition.
- Surface reflectivity test of mirrors/reflectors.
- Absorptivity and emissivity test of receivers.

2.3.4.1 Testing of Receiver (Schott PTR70):

Establishment of the Heat Loss testing of receiver of the parabolic trough collector system was initiated during 2015-16 at NISE (Fig. 2.15).



Figure. 2.15: Heat loss testing of heat receiver

2.3.4.2 Reflectivity Testing of Mirrors

During 2015-16, NISE has tested reflectivity of mirror used in paraboloid dish, parabolic trough collector and heliostat technologies and its reflectivity with different wavelengths. The system and the test results are given in Figures 2.17 & 2.18



Fig. 2.17: Reflectivity testing of different mirrors of Reflectors

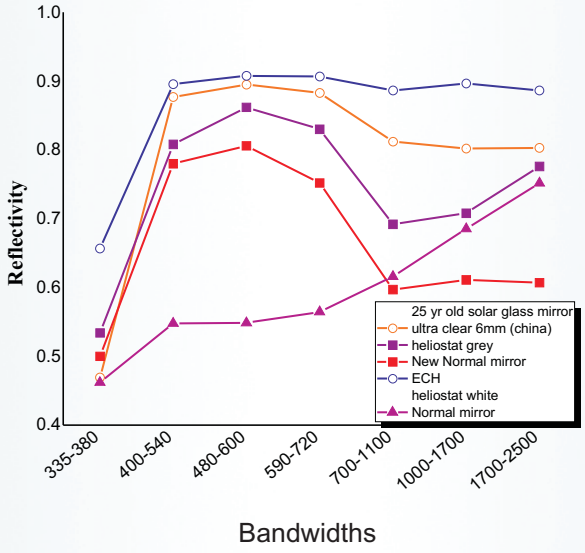


Fig. 2.18: Reflectivity testing of different mirrors at various bandwidth

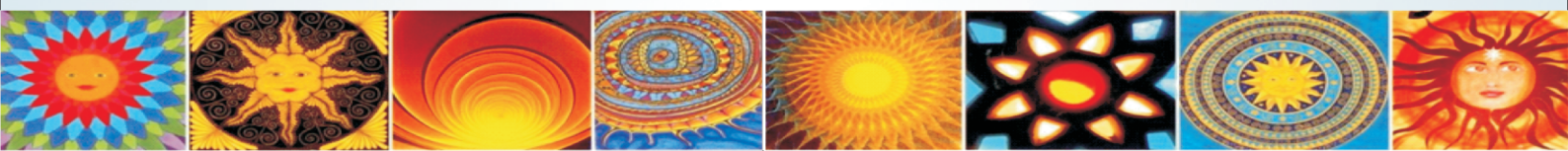
Table 6 shows the average reflectivity of the different mirrors manufactured by various mirror manufacturers and it is observed that the new generation mirrors show comparatively less reflectivity than the old ones. The reflectivity of a 25 year old mirror is still close to 90 % and the variation in the new mirrors is from 57% to 90%. The information is relevant for new entrepreneurs/manufacturers of solar thermal technologies.

Table 6: The average reflectivity of different mirror manufacturers

Mirrors Manufacturers	Average Reflectivity
PTC Technology installed in 1988 at NISE (more than 25 years exposer of sun)	0.907
ECH	0.876
Ultra-Clear 6mm (china)	0.826
Saint-Gobain	0.927
Asahi	0.754
Normal mirror	0.572
New Normal mirror	0.675

2.3.5 Mobile Test Set Up

Mobile test facility has also been procured for testing and performance evaluation of different solar thermal technologies in actual working/field conditions. The test facility consists of weather parameter equipment, temperature sensors, flow measurement equipment including ultrasonic flow meter, data logger, reflectivity and absorptivity test equipment. The test equipment are shown below in Fig. 2.19 and Fig. 2.20.



Mobile solar tracker with irradiation sensors	
Ambient temperature and wind sensors	
Clamp-on ultrasonic flow meter	
Temperature sensors	
NIR Handheld Reflectometer	
Mobile data loggers	

Fig. 2.19: Mobile Test Equipment

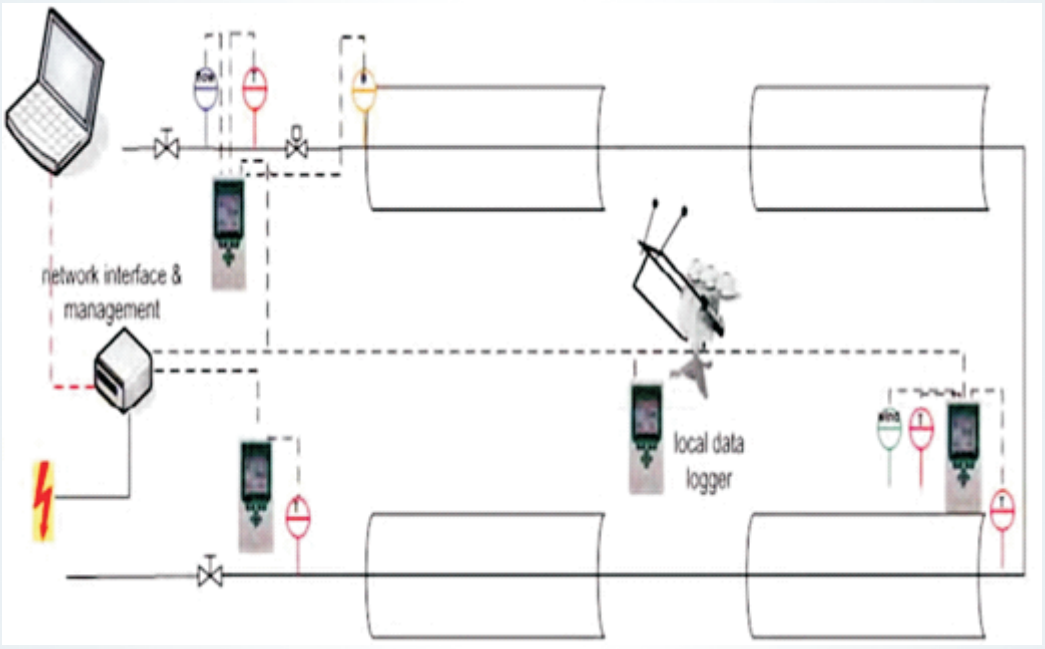


Figure. 2.20: Mobile test setup for different CSTs

A team was deputed to evaluate the performance testing of Scheffler reflector at Ludhiana, Punjab in March, 2016. The team has tested the system as per the specifications given in Table 7.

Table 7: Specifications of the Scheffler system

System beneficiary	Soft Tech Renewable Energies
Location	Ludhiana, Punjab
Date of Testing	8^{th} – 11^{th} March 2016
Installed Solar Technology	Scheffler Reflector
Total Aperture Area Of Collector	16 m^2
Application	Hot water generation
Working Fluid	Water
Processing Temperature	80 °C

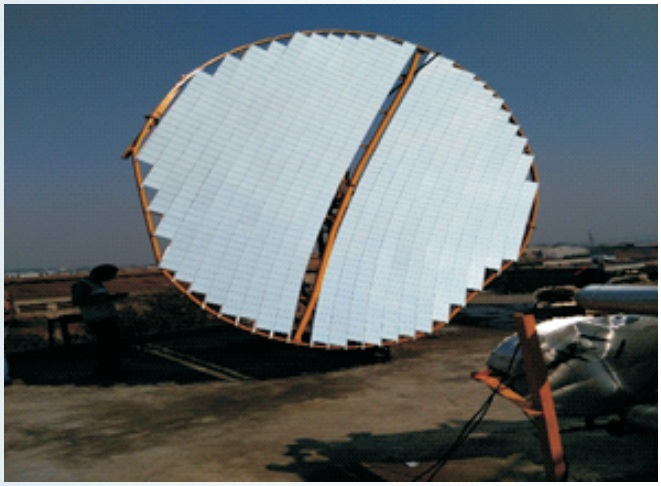


Fig. 2.21: Scheffler system installed at Ludhiana

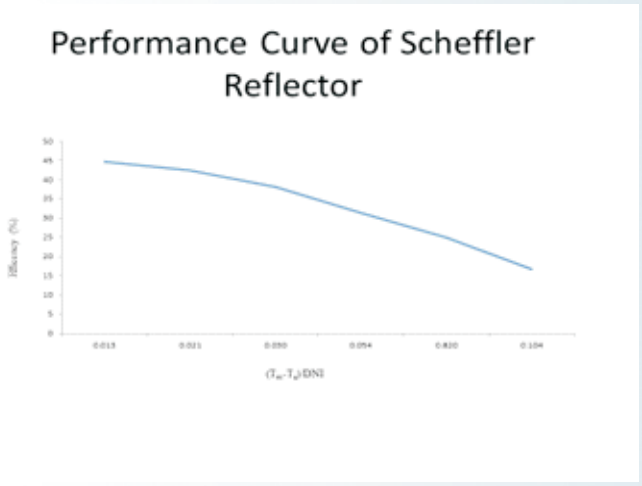


Fig. 2.22: Characteristic curve of the Scheffler system

The results show that the optical efficiency of the Reflector has reached 45% at DNI 700 W/m^2 and at ambient temperature of 30 ^{0}C

2.4 Solar Radiation Resource Assessment (SRRA)

2.4.1 Introduction

Solar Radiation Resource Assessment (SRRA) is a flagship program of Ministry of New and Renewable Energy (MNRE) launched in the year 2010, setting up the world's largest network of ground measurement solar radiation resource assessment stations all over the country. The project aims to overcome the deficiencies in the availability of investor grade ground measured solar radiation data crucial for planning and implementation of solar power projects

2.4.2 Major Activities in 2015-16

The focus of the SRRA division has been on the following major activities:

a) Analysis of Radiation Data of various other SRRA locations in the country.

b) Preparation of a solar map to identify feasible locations for various solar applications.

c) Data monitoring and maintenance of SRRA station at NISE, Gurgaon.

d) MoU has been signed with National Remote Sensing Centre, Hyderabad and ISRO for collaborative research in Solar Radiation from Satellite images.

e) Experimentation to understand the effect of soiling on the radiation measurements.

f) ArC GIS software for the representation of various Solar Radiation data has been purchased.

g) A two day skill development program to disseminate the knowledge in the field of Solar Resources is planned for May 2016.

h) A book chapter titled "Mapping of Indian Locations for Concentrated Solar Thermal applications based on Ground based solar irradiation data" has been published in Advances in Solar Energy, Science and Engineering, an Annual RD&D Review Vol.2, published by TTP.

2.4.3 Solar Radiation Calibration Laboratory (SRCL)

Solar Radiation Resource Assessment Division has set up a Solar Radiation Calibration Laboratory as per the guidelines of World Meteorological Organization (WMO) for calibration of solar radiation sensors operating in the field in north India in collaboration with Solar Energy Corporation of India. The objective of the Project is to calibrate the solar radiation sensors operating at various SRRA stations as per International standards, having their traceability to World Radiation Center (WRC), as stated in WMO guidelines. The various International standards that are being used at the laboratory for calibration are ISO 9847, ISO 9059 and ISO 9060

The following types of sensors can be calibrated at SRCL are

- Pyranometer (Thermopile Based) – Measures Global Horizontal Irradiance (GHI) and Diffuse Horizontal Irradiance (DHI).
- Pyrheliometer - Measures Direct Normal Irradiance (DNI).

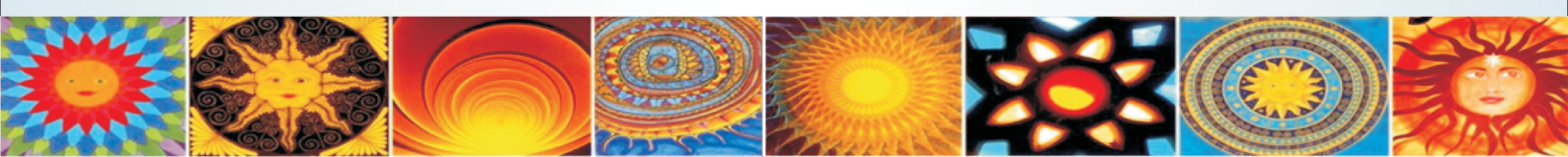
The laboratory is equipped with facility to calibrate 6 No. of Pyranometers (Thermophile based sensor) and 3 No. of Pyrheliometer at a time. Presently the laboratory can calibrate the radiation sensors from the companies such as Eppley lab., Kipp&Zonen and Huseflux whose sensors are being widely used all over world. The laboratory is equipped with primary standard as Absolute Cavity Radiometer (ACR), Model AHX by Eppley lab directly traceability to World Radiation Center (WRC). The reference standard that is being used at the laboratory for calibration of field Pyranometer sensors belong to category of 'Secondary Standard 'and is supplied by Eppley lab. Similarly the reference standard for calibration of field Pyrheliometer sensor belong to class of 'Secondary Standard 'and is also supplied by Eppley lab. .

2.4.4 Activities carried out in 2015-2016

SRCL had calibrated sensors from 3 no. of SRRA Stations (9 no. of Sensors) in Rajasthan out of the given target 51 no. of SRRA stations situated in the northern region of India and also calibrated 2 no. of sensors from UNDP thermal lab, NISE. Total 11 no. of sensors calibrated and issued calibration reports till March, 2016. The list of instruments available in the solar Radiation Calibration laboratory (SRCL) at NISE is as given below :

Solar Radiation Measuring Instruments:

Sl. No	Instrument name	Make/model	Standard
1	Absolute Cavity Radiometer – ACR	Eppley/ AHF-AWX	Primary
2	Pyranometer	Eppley/ PSP	Secondary
3	Pyrheliometer	Eppley/ NIP	Secondary



Meteorological Instruments:

Sl. No.	Instrument Name	MAKE/MODEL
1	Pressure Indicator	Druck/ DPI740
2	Hygrometer (Relative Humidity)	Rotronic meter/ HP21
3	Rain Gauge Calibration	R.M. Young/52260
4	Wind Sensor (2 axes) Ultrasonic Anemometer with display units	R.M. Young/85000

Strength of staff in Solar Radiation Calibration Laboratory (SRCL), NISE-SECI has been increased as below:

Sl. No.	Designation	No. of Staff
1	Project Engineer	2
2	Supervisor (Technical)	4
3	Computer Operator	1
4	Lab Attendant	1
Total		8

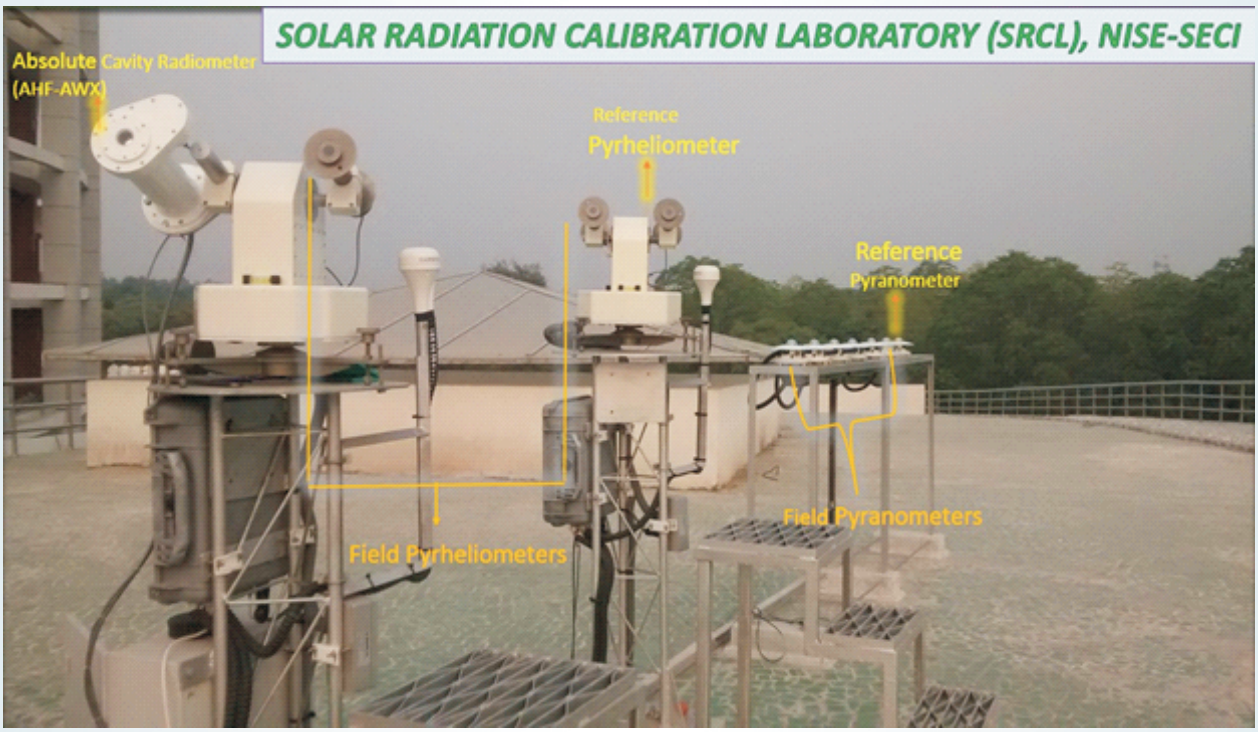


Fig. 2.23: Solar Radiation Calibration Laboratory (SRCL) facility at NISE

Chapter-3

Skill Development & Consultancy Division

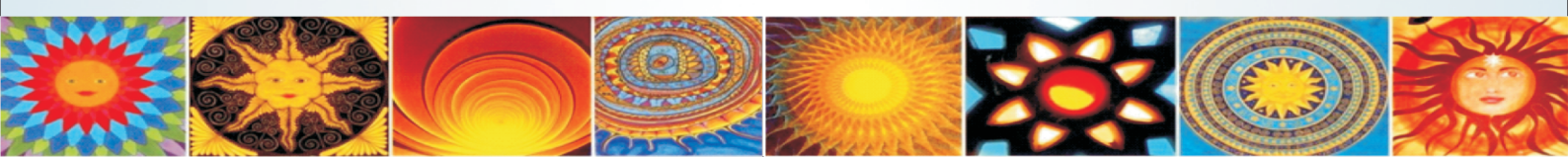
"Skilling India" is the dream project of Honorable Prime Minister of India for creating job opportunities for the unemployed youth in various service and manufacturing sectors throughout the country. It is a flagship program of the PMO targeting to create 500 million skilled manpower by 2020.

Renewable energy is one of the targeted sectors, and National Institute of Solar Energy (NISE) is assigned with the responsibility of executing various skill development programmes throughout the country in the field of renewable energy technologies, with a clear focus on Solar Energy. During 2014-15, NISE has created innovative, result oriented Skill Development Division to cater the needs of "Make in India" program and for India to achieve the target of 175 GW of Renewable Energy which includes 100 GW of Solar Energy by 2022. Annually various training programs targeting different segments are being conducted at NISE campus as well as at its partner institutes across India. Details of the training programs conducted by the Skill Development Division of NISE during FY 2015-16 are as follows:

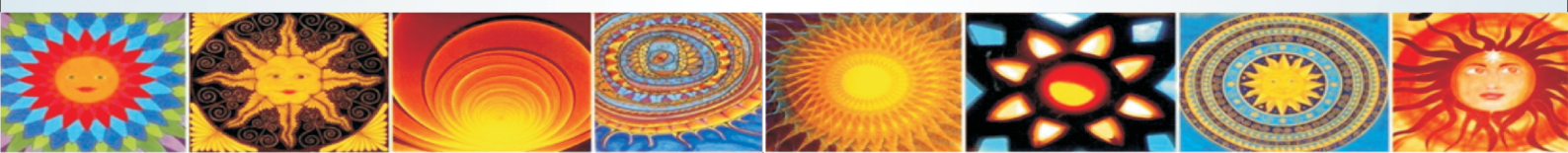
1. Skill Development Activities at NISE

NISE, formerly Solar Energy Centre, has been conducting training in Renewable Energy Technologies with a clear focus on Solar Energy Technologies for the past two decades for national and International Participants. NISE is regularly inviting experts from renewable energy and solar industry and interacts with them to identify the skill gaps among the new recruits of the renewable energy industry. NISE has developed curriculum and content for renewable energy technologies skill development programs, designed for senior Defence ministry officials and conducted three programs during the year. During 2015-16, 32 training programs at the NISE campus and different parts of the country were conducted by NISE.

The following Skill development programs were conducted at NISE during 2015-16:



S No	**Name of the Skill Development Program**	**Dates**
1.	Operation & Maintenance SPV Power Plants (2nd Batch of BSF Officers)	May 13-15, 2015
2.	"Suryamitra" Solar Photovoltaic Skill Development Program	June 15-26, 2015
3.	Grid Integrated Rooftop Solar PV Technology and Design	July 21-23, 2015
4.	Off grid Rooftop Solar PV Technology and Design	July 28-30, 2015
5.	Renewable Energy Technologies Workshop for Armed Forces	August 03-07, 2015
6.	"Suryamitra" Skill Development Program (1st Batch)	Sept 03 – Dec 03, 2015
7.	Solar Water Heating program	September 16-18, 2015
8.	Grid Integrated Rooftop Solar PV Technology and Design	Sept 29 - Oct 01, 2015
9.	Training of Trainers (ToT) Program for Suryamitra Trainers	October 5 – 9, 2015
10.	Training Program on Energy Access	Nov 17-19, 2015
11.	Training of NISE Staff in PVSyst / PV*SOL Simulation Software for NISE Staff	Nov 18-19, 2015
12.	Varun Solar Water Pumping Program	November 25-29, 2015
13.	Solar Water Heating program	December 2-4, 2015
14.	Training Program on Energy Access at NISE Gurgaon	December 16-18, 2015
15.	Renewable Energy Rural Livelihoods, Ratlam, Madhya Pradesh	December 10-12, 2015
16.	Renewable Energy Rural Livelihoods, Hoshangabad, Madhya Pradesh	December 15-17, 2015
17.	Renewable Energy rural Livelihoods, Betul, Madhya Pradesh	December 18-20, 2015
18.	Renewable Energy Rural Livelihoods, Balaghat, Madhya Pradesh	December 21-23, 2015
19.	Renewable Energy Rural Livelihoods, Kharupetia, Assam	November 25-27, 2015
20.	Renewable Energy Rural Livelihoods, Nalbari, Assam	December 15-17, 2015
21.	Renewable Energy Rural Livelihoods, Goalpara, Assam	December 24-26, 2015
22.	Renewable Energy Rural Livelihoods, Barpeta, Assam	December 28-30, 2015
23.	Renewable Energy Rural Livelihoods, Bhubaneswar, Orissa	December 1-3, 2015
24.	Renewable Energy Rural Livelihoods, Koraput, Orissa	December 11-13, 2015
25.	Renewable Energy Rural Livelihoods, Kalahandi, Orissa	December 23-25, 2015
26.	Renewable Energy Rural Livelihoods, Bhubaneswar, Orissa	December 29-31, 2015
27.	"Suryamitra" Skill Development Program (2nd Batch)	Jan 01 to March 31, 2016
28.	Skill Development Program for Chartered Engineers	February 2-4, 2016
29.	Renewable Energy Technologies Workshop for Armed Forces	February 8-12, 2016
30.	Skill Development Program for SJVNL Officials on PV Syst/ PVSOL (Batch 1)	Feb 8-9, 2016
31.	Skill Development Program for SJVNL Officials on PV Syst/ PVSOL (Batch 2)	Feb 10-11, 2016
32	Training of Trainers (ToT) Program for Suryamitra Trainers	March 8-10, 2016
	Total number of Programs	**32**





Training Program on Renewable Energy for Rural Livelihoods at Goalpara, Assam (Dec 2015)



Skill Development program on Solar Energy for Chartered Engineers (Feb 2016)



Renewable Energy Technologies Workshop for Armed Forces (Feb 2016)



Training of Trainers (ToT) for Suryamitra Program (2nd batch) (March 2016)

2. "Suryamitra" Skill Development Program

Govt. of India intends to achieve the target of 175 GW which includes 100 GW from Solar Energy by 2022. "Make in India" is an initiative of the Hon'ble Prime Minister to encourage multinational and domestic companies to manufacture their products in India. Suryamitra initiative is also a part of Make in India. To achieve and maintain the target of 100 GW solar power plants for 25 years, India requires about 6.5 lakh personnel, trained in solar energy sector (estimated by CII).

The objective of the Suryamitra Program is to provide employability and entrepreneurship to rural and urban youth & women. Special emphasis is given to skill youth from SC/ST/OBC categories. The qualification required to participate in the program is ITI (Electrical & Wireman)/ Diploma in Engineering (Electrical, Electronics & Mechanical). B Tech/ B.E. degree holders are not eligible. Each batch has a maximum strength of 30.

MNRE has set a target of 50,000 "Suryamitras" of skilled manpower in solar energy sector in next 3 years. As on date more than 3,200 Suryamitra have been trained under the program. The target for FY 2016-17 is to train 7,000 Suryamitra's.

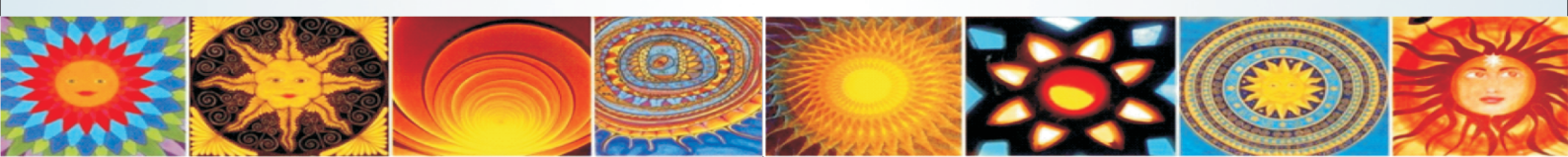
Suryamitra course is a 3 months duration skill development program designed to create skilled manpower in installation, commissioning, and operation & maintenance of solar power plants and equipment. The course teaches the basics of electrical, SPV applications and solar power plant including standards, preventive maintenance, trouble shooting etc. The first month of the program is dedicated to Basic Electricity, followed by SPV in second month. The third month is dedicated for internship in SPV industries and EPC projects. The course is jointly designed by MNRE and NISE.

NISE is the apex body to implement the program across the country, in association with State Nodal Agencies (SNAs). "Suryamitra" is a residential program which is 100% funded by Govt. of India and implemented by NISE across the country. The institutes like universities, polytechnics, ITIs etc. are executing the "Suryamitra" skill development program at various locations in the country. So far more than 118 institutes in 25 states are implementing the Suryamitra program and creating job opportunities to the unemployed youth.

The overall program is designed with 30% theory and 70% lab work and experimentation. Daily quiz, group exercises and various types of competitions are part of the program. For the purpose of maintaining the motivation level, the students are recognized on the basis of their achievements in various subjects.

During the course, the students are supposed to appear for weekly tests at the end of every week, followed by a monthly test at the end of each month. In the end of the course a third party assessment is conducted by NCVT.

About 80% of the Suryamitras are placed in various solar industries with decent salaries. The rest are becoming entrepreneurs in the field of solar energy.



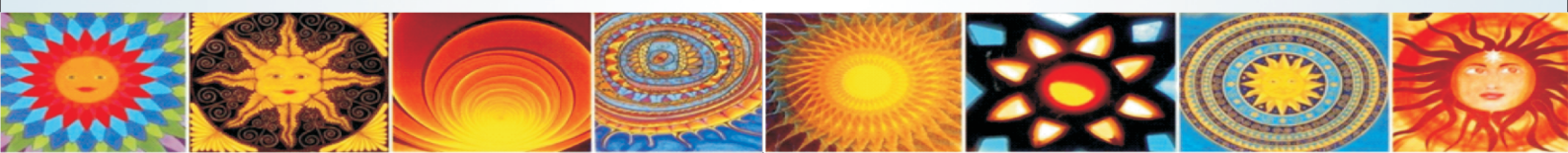
3. "Suryamitra" Programs on PAN India basis

NISE invited applications from Institutes of high repute across the country to conduct Suryamitra programs through respective State Nodal Agencies (SNAs). NISE received massive response from Institutes across the country. Scrutinizing the right Institute was first carried out by SNAs and further by NISE through personal visits of its SPV experts to almost all the Institutes individually to verify their infrastructure facilities, class room facilities, accommodation facilities lab facilities and availability of trainers, etc. Affiliations were given to Institutes which fulfilled the basic eligibility criteria as well as the technical norms as specified by NISE.

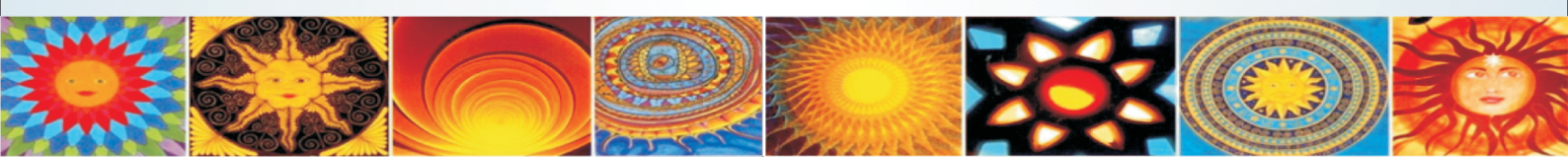
In parallel, NISE prepared guidelines for conducting Suryamitra programs with stringent quality norms along with standards for basic infrastructure, lab work, equipment, class rooms and other support facilities. The course curriculum of NCVT (Module 5, Solar PV Technicians Course) was taken as reference document which was further elaborated to make it equivalent to global standards.

As on March 31, 2016 the following 118 Institutes have been approved for imparting training to Suryamitras:

S No	State	Training Institute	Contact Person
1.	Andhra Pradesh	Acharya Nagarjuna University	ANU office 0863 234 6252
2.	Andhra Pradesh	ADS Global Knowledge Academy	Mr. Deepankar 7838784466
3.	Andhra Pradesh	Aveon Technovations	Mr Sai Sundar 7893566655
4.	Andhra Pradesh	ITDA Chintoor, Distt East Godavari	NEDCAP 040 2403 6869
5.	Andhra Pradesh	ITDA Rampachodavaram, Distt East Godavari	Asstt Proj. Officer 08864-243536
6.	Andhra Pradesh	Minerva ITI Prathipadu	NEDCAP 040 2403 6869
7.	Andhra Pradesh	Surabhi Education Society	Mr Shekhar 8008327873
8.	Andhra Pradesh	Jawaharlal Nehru Technological University, Ananthapur	NEDCAP- 040-24036869
9.	Andhra Pradesh	Vishaka Technical Campus, Narava, Vishakhapatnam	Prof. G. Gagadeesh Kumar 9490491157
10.	Andhra Pradesh	Govt. Residential Polytechnic, Paderu	Prof. G. Gagadeesh Kumar 9490491157
11.	Andhra Pradesh	Maharaja Vijayaram Gajapathi Raj College of Egg. Vizianagaram	NEDCAP- 040-2403689
12.	Arunachal Pradesh	NB Institute of Rural Technology	Dr SP Gonchaudhary 09831079359
13.	Assam	NB Institute of Rural Technology	Dr SP Gonchaudhary 09831079359
14.	Assam	Tejpur University, Guwahati	Mr. M.K. Chaudhary 0361-2464618, 2450646
15.	Bihar	Beltron Telecom Green Energy Systems Ltd	Ramesh Kumar 0612-2228540
16.	Bihar	Husk Power	Baljeet Singh 7542028152
17.	Bihar	NIT Patna	Prof S.K. Verma
18.	Chandigarh	Panjab University	CRESToffice 0172-2771919

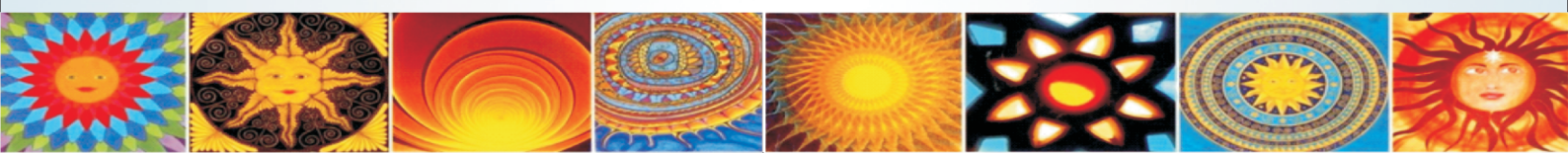


19.	Chhattisgarh	Bhilai Institute of Technology, Raipur	BITR office 0771-2120232
20.	Chhattisgarh	Disha Education Society	CREDA 077140 19226
21.	Chhattisgarh	SR Corporation, Raipur	SRC office 0771-2430535
22.	Chhattisgarh	Chhattisgarh Training & Research Organization Bhilai	Mob: 07714019230
23.	Delhi NCT	TERI, New Delhi	Mr Gautam 9599277874 Ms Abhisha Raj 9555042454
24.	Delhi NCT	ADS Global Knoledge Academy	Mr. Deepankar 7838784466
25.	Goa	Everonn skill development ltd	Ms Anupa 09423311868
26.	Gujarat	Aspire Disruptive Skill (ADS) Foundation, Ahamdabad	Mr Satyanarayan 8454041233
27.	Gujarat	Aspire Disruptive Skill (ADS) Foundation, Bhavnagar	Mr Satyanarayan 8454041233
28.	Gujarat	Aspire Disruptive Skill (ADS) Foundation, Surendra Nagar	Mr Satyanarayan 8454041233
29.	Gujarat	Aspire Disruptive Skill (ADS) Foundation, Dhandhuka	Mr Satyanarayan 8454041233
30.	Gujarat	Aspire Disruptive Skill (ADS) Foundation, Dhangadra	Mr Satyanarayan 8454041233
31.	Gujarat	Aspire Disruptive Skill (ADS) Foundation, Porbandar	Mr Satyanarayan 8454041233
32.	Gujarat	Aspire Disruptive Skill (ADS) Foundation, Dahod	Mr Satyanarayan 8454041233
33.	Gujarat	Darshan Institute of Engg. & Tech, Rajkot	DIET office 02822-293010, 293011
34.	Haryana	Govt. Polytechnic, Ambala	HAREDA 0172-2587233, 2587833.
35.	Haryana	Govt. Polytechnic, Hisar	HAREDA 0172-2587233, 2587833.
36.	Haryana	Govt. Polytechnic, Narnaul	HAREDA 0172-2587233, 2587833.
37.	Haryana	Govt. Polytechnic, Nathusan Chopta, Sirsa	HAREDA 0172-2587233, 2587833.
38.	Haryana	Govt. Polytechnic, Sonipat	HAREDA 0172-2587233, 2587833.
39.	Jammu & Kashmir	Govt. Women Polytechnic Bemina, Srinagar	Mr. Khalid 9906963088
40.	Karnataka	Mahatma Gandhi Institute of Rural Energy & Development, Bangalore	MGIRD office 080-23626359, 23626493
41.	Karnataka	SDM College of Engineering & Technology, Dhavalagiri, Dharwad, Karnataka	SDM College 0836-2447465, 2448327

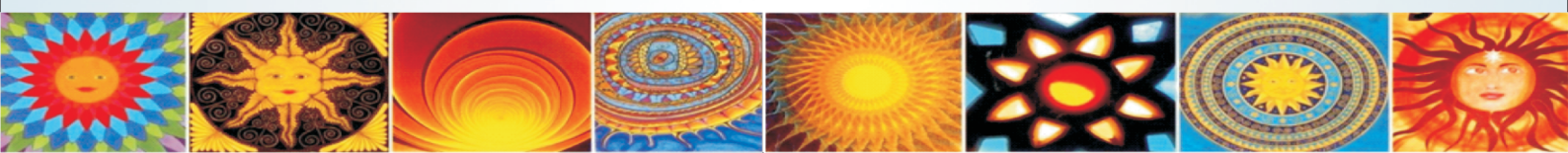


42.	Karnataka	SDM Institute of Technology, Ujire	Contact No. 08256236961
43.	Kerala	AKNM Govt Polytechnic College, Malappuram	Mr. Madhu S 0471-2338077
44.	Kerala	Centre for Development of Imaging Technology (C-DIT), Thiruvananthapuram (Govt.)	Mr. Madhu S 0471-2338077
45.	Kerala	Renewable Energy Centre, Ernakulam	Mr. Madhu S 0471-2338077
46.	Madhya Pradesh	Adarsh ITI Bhopal	MPUVN 755- 2556566
47.	Madhya Pradesh	CESR, Devi Ahahilya Vishvayidyala, Indore	Dr. S.P. Singh 0731-2462366, 2460309
48.	Madhya Pradesh	Dr. B.R. Ambedkar Polytechnic College, Gwalior	Mr Shashi Viksit 09301101447
49.	Madhya Pradesh	Govt. ITI Hoshangabad	MPUVN 755- 2556566
50.	Madhya Pradesh	Govt. ITI Muraina	MPUVN 755- 2556566
51.	Madhya Pradesh	Govt. ITI Rewa	MPUVN 755- 2556566
52.	Madhya Pradesh	Govt. ITI Sagar	MPUVN 755- 2556566
53.	Madhya Pradesh	Kalaniketan Polytechnic College, Jabalpur	Mr R.C. Pandey 09425370157 Mr Ravindra Taksande 09993247201
54.	Madhya Pradesh	Sardar Vallabh Polytechnic College, Bhopal	Mr K.V. Rao 08989208389 Mr U.K. Soni 09827079343
55.	Madhya Pradesh	Shri Vaishnav Polytechnic College, Indore	Mr S.S. Sharma 09303240302
56.	Madhya Pradesh	Ujjain Polytechnic College, Ujjain	Mr S.K. Sastry 09425915947 Mr Ravindra Sharma 09826151448
57.	Maharashtra	Maharashtra Centre for Entrepreneurship Development, Amravati	Mr Sudan Thorte 9403078753
58.	Maharashtra	Maharashtra Centre for Entrepreneurship Development, Aurangabad	Mr Sudan Thorte 9403078753
59.	Maharashtra	Maharashtra Centre for Entrepreneurship Development, Chandrapur	Mr Sudan Thorte 9403078753
60.	Maharashtra	Maharashtra Centre for Entrepreneurship Development, Dhule	Mr Sudan Thorte 9403078753

61.	Maharashtra	Maharashtra Centre for Entrepreneurship Development, Kohlapur	Mr Sudan Thorte 9403078753
62.	Maharashtra	Maharashtra Centre for Entrepreneurship Development, Latur	Mr Sudan Thorte 9403078753
63.	Maharashtra	Maharashtra Centre for Entrepreneurship Development, Nagpur	Mr Sudan Thorte 9403078753
64.	Maharashtra	Maharashtra Centre for Entrepreneurship Development, Nanded	Mr Sudan Thorte 9403078753
65.	Maharashtra	Maharashtra Centre for Entrepreneurship Development, Nasik	Mr Sudan Thorte 9403078753
66.	Maharashtra	Maharashtra Centre for Entrepreneurship Development, Pune	Mr Sudan Thorte 9403078753
67.	Maharashtra	Maharashtra Centre for Entrepreneurship Development, Raigarh	Mr Sudan Thorte 9403078753
68.	Maharashtra	Maharashtra Centre for Entrepreneurship Development, Sangli	Mr Sudan Thorte 9403078753
69.	Maharashtra	MITCON - Amravati	Mr Abhay Kulkarni 9822695876
70.	Maharashtra	MITCON - Aurangabad	Mr Abhay Kulkarni 9822695876
71.	Maharashtra	MITCON - Dhule	Mr Abhay Kulkarni 9822695876
72.	Maharashtra	MITCON - Nagpur	Mr Abhay Kulkarni 9822695876
73.	Maharashtra	MITCON - Nanded	Mr Abhay Kulkarni 9822695876
74.	Maharashtra	MITCON - Nashik	Mr Abhay Kulkarni 9822695876
75.	Maharashtra	MITCON - Satara	Mr Abhay Kulkarni 9822695876
76.	Maharashtra	MITCON - Solapur	Mr Abhay Kulkarni 9822695876
77.	Maharashtra	MITCON - Wardha	Mr Abhay Kulkarni 9822695876
78.	Maharashtra	MITCON - Washim	Mr Abhay Kulkarni 9822695876
79.	Maharashtra	MITCON - Yeotmal	Mr Abhay Kulkarni 9822695876



80.	Manipur	NIELET, Imphal : Govt. Organization	Mr M. Dinamani Singh 9856153172
81.	Nagaland	2E Knowledge Ventures Pvt Ltd	Directorate of New & Renewable Energy 0370-2242565
82.	NISE	The Gandhigram Rural Institute, Tamil Nadu	Mr Kirubakaran 09443859066
83.	NISE	IL&FS Andhra Pradesh	Mr Gaurang 9769007441
84.	NISE	IL&FS Gujarat	Mr Gaurang 9769007441
85.	NISE	IL&FS Madhya Pradesh	Mr Gaurang 9769007441
86.	NISE	IL&FS Rajasthan	Mr Gaurang 9769007441
87.	NISE	IL&FS New Delhi	Mr Gaurang 9769007441
88.	NISE	Kwatt Solution Pvt Ltd (A Company incubated at IITB)	Mr Mehul 7718897036
89.	NISE	L&T Construction Skills Training Institute, Pilkhuwa, Ghaziabad	Mr. Shivam 8010399323
90.	NISE	NISE Campus, Gurgaon	Ms Pallavi Dubey 9891273991
91.	Odisha	OMS Power Training & Research	OMS office 0674-2552984, 2552985
92.	Puducherry	Govt. ITI for Women TR Pattinam, Karaikal	Mr R M Bairavan 04368-233233, 234248
93.	Puducherry	Govt. Polytechnic Lawspet Puducherry	REAP 0413 235 4319
94.	Puducherry	Karaikal Polytechnic College	Mr D. Candane 9443165701
95.	Punjab	Community Polytechnic, Palahi, Distt Kapurthala.	Mr. Ravinder Kumar (Principal) 01824-228533
96.	Punjab	Guru Nanak Dev Polytechnic College, Ludhiana.	Er. Birinder Singh (Principal) 0161-2490654
97.	Punjab	School of Energy Studies, Punjab Agriculture University, Ludhiana	PEDA office 0172 266 3382
98.	Rajasthan	Cairns Energy Center of Excellence	Mr Gyan Sharma 08094006664
99.	Rajasthan	RVS Education, Sikar	Mr Vijay Soni 9116012337
100.	Rajasthan	Vision World tech Pvt. Ltd. Jaipur	Contact No. 8505000866 0141-2229055
101.	Tamil Nadu	Iacharya Silicon Ltd	Visalakshi L. 09790879904
102.	Tamil Nadu	Madhumita Software Services	Mr Nanda Kumar A. 09843706043

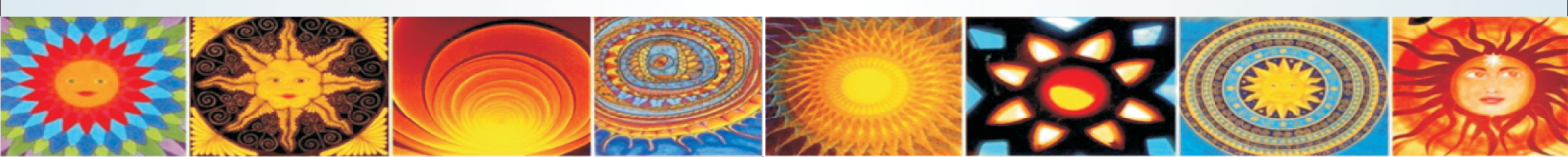


103.	Tamil Nadu	NERD Society Ltd	Dr. S. Kamraj 0422-2422689
104.	Tamil Nadu	Tamil Nadu Advance Technical Training Institute	G. Rajaganeshan 09566156789
105.	Tamil Nadu	Mangla Smart Energy Solution Pvt. Ltd. Tirupur	Mob: 09150570678
106.	Tamil Nadu	Sri Eshwar College of Engineering, Coimbatore	Mob: 07373617171
107.	Telangana	Aveon Technovations	Mr Sai Sundar 7893566655
108.	Telangana	Surabhi Education Society	Mr Shekhar 8008327873
109.	Telangana	Mahaveer Institute of Science & Technology, Hyderabad	Contact- 040-23201502
110	Tripura	Ramkrishna Mission ITI	Mr D.S. Das 0381-2326139
111.	Uttar Pradesh	Centre of Excellence in Renewable Energy Education & Research, University of Lucknow.	Mr. A K Singh 9415609013
112.	Uttar Pradesh	Non-conventional Energy Development Institute (Ghosi), Mau	Mr. A K Singh 9415609013
113.	Uttar Pradesh	UPNEDA Research Development & Training Centre, Chinhat, Lucknow	Mr. A K Singh 9415609013
114.	Uttarakhand	Govt. Polytechnic, Dehradun	Mr Vineet Mall 09410796649
115.	Uttarakhand	Ordinance Factory Dehradun	Mr Vineet Mall 09410796649
116.	Uttarakhand	Govt. Polytechnic Lohaghat	Contact No. 0135-2521553
117.	Uttarakhand	Institute of Engineers, Dehradun	Contact No. 0135-2521553
118.	West Bengal	Environment Conservation Society, Kolkata	Ms Ekta Kothari Jaju 09331118105

4. Quality Control of "Suryamitra" Programs conducted on PAN India Basis

When 118 numbers of Institutes are participating in Suryamitra Program, it is essential to ensure quality of the program offered in all institutes across the country. NISE has developed a detailed check list covering all the aspects starting batch formation to infrastructure and facilities, course curriculum, reading materials, faculty, training aids, conducting training programs, weekly monthly tests, industry visits and internship. This also includes the placement efforts made by the institutes for the students completing this program.

NISE scientists are paying Surveillance visits to all the institutes conducting Suryamitra Programs. The performance of all the institutes is evaluated on the basis of criteria laid-down in the check list. The spontaneous feedback is given to all the institutes for improvements on all the parameters



A third party assessment for the students passing from these institutes is done through NCVT under MSDE (Ministry of skill Development and Entrepreneurship). So far 21 institutes have already completed their assessment. Another 42 are in the advanced stage of their assessment exercise. The candidates who successfully clear the assessment exercise are awarded certificates by NCVT with Govt of India Logo. The certificate carries value at international level.

5. Glimpse of "Suryamitra" Programs conducted on PAN India Basis

During 2015-16, NISE at its campus has conducted 2 Suryamitra training courses, and more than 60 Suryamitra training courses were conducted on PAN India basis by various affiliated training Institutes . A glimpse of the courses conducted are presented below





First Batch of Suryamitra Course conducted at NISE, Gurgaon during September 03–December 03, 2015



Second Batch of Suryamitra Course conducted at NISE, Gurgaon during Jan 01, 2016– March 31, 2016



Suryamitra Course conducted by M/s ADS Global Knowledge Academy in Andhra Pradesh



Suryamitra Course conducted by N B Institute of Rural Technology, Itanagar, Arunachal Pradesh



Suryamitra Course conducted by N B Institute of Rural Technology, Guwahati, Assam



Suryamitra Course conducted by Husk Power Systems Pvt Ltd, Bihar



Suryamitra Course conducted by SR Corporate Consultant Private Limited, Chhattisgarh



Suryamitra Course conducted by MITCON, Nanded, Maharashtra



Suryamitra Course conducted by Gandhigram Rural Institute, Tamil Nadu

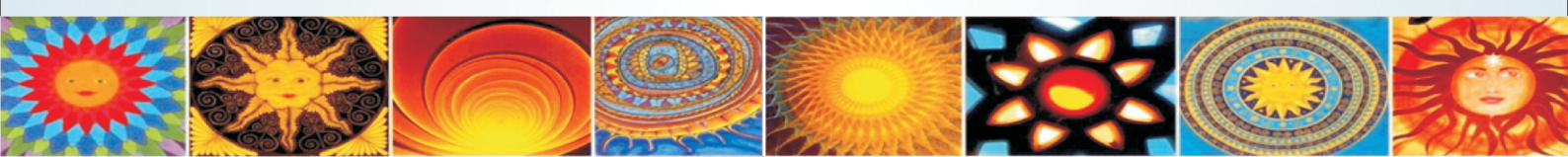
1. "Suryamitra" Mobile APP

NISE has developed GPS based Mobile app called Suryamitra mobile App. It is currently available in Google play store and IOS Platform, which can be downloaded and used across India. This App is a high end technology platform which can handle thousands of calls simultaneously and can efficiently monitor all visits of Suryamitra's. The trained Suryamitra's who opts for entrepreneurship have joined in the Mobile App in several states. These Suryamitras are once again sensitized by NISE on soft skills Customer Relations Management, Punctuality and are now ready to deliver the services.

This innovative mobile approach shall enhance the employment of trained youth in solar PV technology and also improve the businesses of solar entrepreneurs because of quality servicing, maintenance and repairing professionals are now available to customers at the click of a button on their mobiles.

Under NABARD Scheme of Off grid Solar PV system lakhs of off-grid SPV systems have been installed and systems do require regular maintenance. To keep the system in good condition skilled manpower is required, therefore, the proposed technical platform of Suryamitra Mobile App can be utilized for this purpose too. MNRE has an ambitious target of installing 100,000 solar PV pumps in several states. Suryamitra Mobile App would come handy with respect to O & M, repair and maintenance of solar pumps. Similarly, millions of square meter of solar water heater systems are already installed in various states. In order to maintain the existing system and to install new systems properly, Suryamitra App would be very useful.

Overall this technical platform which is very useful in the field of Renewable energy to serve customers at their doorsteps with quality installation, repair, and O&M services. Suryamitras with the help of NISE ensure proper functioning and servicing of Solar PV and thermal systems to all customers. NISE has checks and controls in place to ensure that all Suryamitras offer quality service at reasonable price to their customers. NISE has fixed a price Rs.150/- per visit as visiting charges for Suryamitra Services and for installation and O&M Charges Suryamitra's would charge standard charges as per MNRE advised rates. It is hoped that Suryamitra Mobile App would act as an effective catalyst in creating demand for solar products in the country and in offering employment and business opportunities for Suryamitras.



7. Solar Energy Network (SETNET)

NISE has established the Solar Energy Training Network (SETNET) institutions across India to build skills and capacities to ensure the availability of qualified solar energy professionals to meet the national solar deployment targets.

The objective of SETNET is to ensure the availability of skilled manpower to meet the solar deployment target for 2022. SETNET guiding framework includes:

- Prioritization of training needs with concurrent industry interface.
- Standardized curriculum and content delivered by accredited trainers.
- Training delivery through a range of partner organization

Through a competitive process, NISE has identified 35 SETNET partners across the country which are empanelled by NISE to provide the above four skill development courses. Several programs are launched across India



SETNET Team with 35 SETNET Partners

NISE has created curriculum development teams and curriculum for the following major courses:
The five major courses under this program are given below:

- Aryabhatta Certificate (for high level designers)
- Konark (graduate engineer project management course)
- Surya (for solar field technicians)
- Bhaskar (for Business/ Financial Programs)
- Varun (Solar water Pumping Program):

Brief information about these five major courses are:

- **Aryabhatta** Certificate (for high level designers): This course is meant for engineers with some experience in the solar sector. The aim of this course is to enable the participants to effectively plan, design and operate solar power systems of a range of scales from rooftop collectors and power plants to ultra-megawatts

- **Konark** (Graduate Engineer course).This course is meant for engineers who seek employment as a solar engineers

- **Surya** (for solar field technicians): Surya program is meant for Participants dealing with home lighting system, solar rooftop, street lighting solar water heaters, inverters and batteries, charging stations and solar cookers.

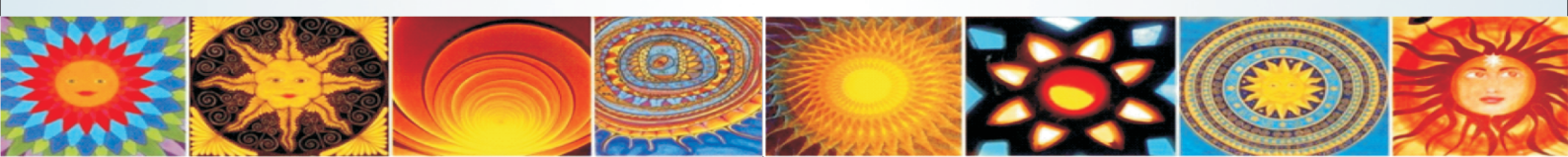
- **Bhaskar** (for Business/ Financial Programs): It deals with the aspects of an policy and regulation, business models, finance, appraising solar projects supply chain management, solar entrepreneurship development and micro finance amongst others.

- **Varun** (Solar Water Pumping Programme): The Program deals with the basics of solar water pumping components, sizing, viability issues, O&M issues and MNRE subsidy guidelines, etc. The target audience are farmers, water pumping public sector undertaking officials, water pump mechanics, and officials of State Agriculture Depts., Discom, State Energy Departments, Govt. of India and State Nodal Agencies, etc.

8. Indian Technical and Economic Cooperation Program (ITEC)

Ministry of External Affairs, Govt. of India has identified NISE as a premier institute to conduct ITEC programs every year for international participants. For the past several years NISE is conducting about two to three programs of ITEC every year to the satisfaction of MEA & the participating countries. This program is a three-week program focused on latest renewable energy technologies particularly Solar Energy. During the year 2015-16, NISE has conducted two ITEC programs. These programs were organized under ITEC and Special Commonwealth Assistance for Africa Program (SCCAP) Programs and these programs were fully funded by Ministry of External Affairs, Govt. of India.

ITEC-1 Programme was conducted during the month of November 2015 covering 22 countries i.e. Cameroon, Egypt, Guatemala, Iran, Jordan, Kenya, Laos, Nepal, Niger, Nigeria, Palestine, Paraguay, Russia, South Africa, St. Lucia, Sudan, Suriname, Syria, Tanzania, Togo, Tunisia and Vietnam with the total number of 27 participants in this program. It is 3 weeks duration course. During this course, NISE also conducted visits to Taj Mahal, Red Fort, Qutub Minar etc. in order to show our rich Indian culture.





ITEC-1 Participants at the Class Room Sessions



ITEC-1 Participants during a Solar PV Rooftop Plant Visit

ITEC-2 Programme was conducted in the month of December 2015 covering 13 countries i.e. Afghanistan, Ethiopia, Ghana, Indonesia, Kazakhstan, Kenya, Madagascar, Malawi, Marshall Island, Mauritius, Myanmar, Sudan and Uzbekistan with the total number of 14 participants.



ITEC-2 Participants with NISE Senior Staff



ITEC-2 Participants at Taj Mahal, Agra

9. International Solar Alliance (ISA):

Under the International Solar Alliance (ISA) is an Indian initiative, NISE has been given the responsibility by Interim Administrative Cell at MNRE to conduct the training program for the ISA member countries. NISE has already submitted 15 proposals i.e. 9 for technical, 2 for banking/ financial, 2 for policy and 2 for entrepreneurship development to Ministry of New & Renewable Energy for conducting the programs for ISA member countries. NISE is also temporarily hosting secretariat for ISA in its premises

10. Visit of Seychelles delegation to NISE in February 2016:

Seychelles is one of the member country of ISA. Senior officials from Seychelles visited NISE campus in the month of February 2016 learned about NISE research and training activities



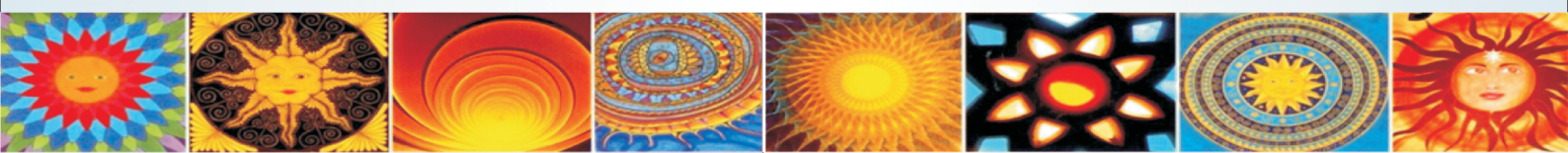
Group Photo of Seychelles delegation with NISE officials in February 2016

11. Upcoming International Training Programs

NISE has planned the following International Training Schedule for the upcoming financial year 2016-17:

S No	Program	Countries	Duration (in weeks)	No of participants	Proposed Dates
1	Eurasia	Afghanistan, Iran, Uzbekistan, Azerbaijan, Kazakhstan, Tajikistan	2	30	Aug 2016
2	SAARC 1	Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, Pakistan and Sri Lanka	3	30	Sep 2016
3	ASEAN 1	Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar,Philippines, Singapore, Thailand, and Vietnam	2	25	Oct 2016
4	ASEAN 2	Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar,Philippines, Singapore, Thailand, and Vietnam	2	25	Nov 2016
5	Indian Africa Forum Summit (IAFS-III) – 1 (South / Southern Africa)	South Africa , Zambia, Namibia, Angola, Zimbabwe, Mozambique, Madagascar, Botswana	3	40	Nov 2016
6	ITEC / SCCAP 1	As Per MEA Guidelines	3	30	Nov 2016
7	Indian Africa Forum Summit (IAFS-III) – 2 (West / Western Africa)	Nigeria, Senegal ,Ghana, Republic of Cote d'Ivoire ,Democratic Republic of Congo, Sierra Leone ,Central African Republic, Liberia	3	40	Dec 2016
8	Indian Africa Forum Summit (IAFS-III) – 3 East / Eastern Africa	Kenya,Ethiopia,Tanzania,Uganda ,Mauritius,Seychelles,Somalia,Rwanda	3	40	Jan 2017
9	ITEC / SCCAP 2	As Per MEA Guidelines	3	30	Jan 2017
10	Indian Africa Forum Summit (IAFS-III) – 4 (North Africa)	Algeria ,Egypt, Sudan, South Sudan, Eritrea ,Libya ,Tunisia, Morocco	3	40	Feb 2017
11	ISA Training	121 countries – 15 Programs	3	30 (per Program)	2016-17 & 2017-18

NISE proposes to further expand international capacity building training programs in future

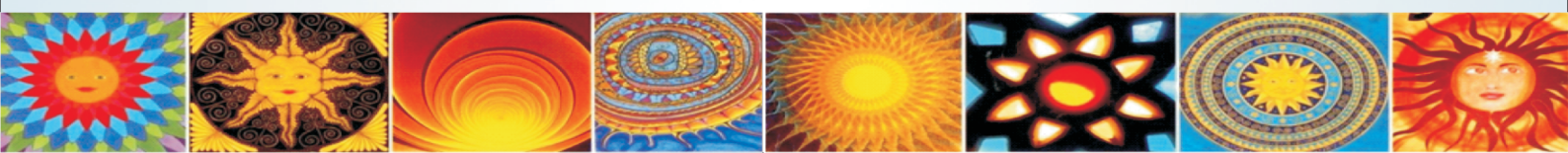


12. Consultancy

With excellent pool of scientific manpower and management experts NISE is handling various consultancy projects on solar photovoltaic and solar thermal technologies. NISE has provided consultancy services to the Ministry of Food Processing, Ministry of Defence, Kandla Port Trust, ISRO, Doordarshan, NLC, NEEPCO, National Seeds Corporation Ltd, National Fisheries Development Board, etc. The consultancy includes techno-economic viability, feasibility reports, detailed project reports, technical specifications, project management advisory, clients' engineers, EPC advisory services etc. NISE is also providing expertise to corporates to set a SPV power plants

The following feasibility/ detailed project reports/ advisory services were given during 2015-16:

S No.	Name of the Project	MW Capacity Suggested / Estimated in the Feasibility Report
1.	Air Force Station, Phalodi, Rajasthan	2
2.	Air Force Station Jodhpur, Rajasthan	2
3.	Air Force Academy, Hyderabad	2
4.	Air Force Station, Hakimpet, Hyderabad	2
5.	Air Force Station, Bidar, Hyderabad	2
6.	Air Force Base, Leh (Ladakh), J&K	1.80
7.	Durbukh Indian Army Base, Leh (Ladakh, J&K	1.5
8.	Tangtse Indian Army Base, Leh (Ladakh), J&K	1.5
9.	Indian Army Base, Roorkee, Uttrakhand	2
10.	Indian Army Base, Dehradun, Uttarakhand	2
11	Indian Army Base, Saharanpur (UP)	0.50
12	Abhera Army Training Centre, Kota, Rajasthan	2
13	Army Base at Itarana Cantt, Alwar, Rajasthan	2
14	Air Force Station, Bhuj, Gujarat	3
15	Air Force Station, Barmer, Rajasthan	3
16	Air Force Station, Jaisalmer, Rajasthan	3
17.	Nal, Bikaner, Rajasthan	1.5 MW
18.	Bhatinda, Punjab	2.0 MW + 5 MW
19.	Bhisiana, Punjab	1.0 MW
20.	Sri Ganganagar, Rajasthan	2.0 MW
21.	Suratgarh, Rajasthan	2.0 MW
22.	Jalandhar, Punjab	2.0 MW
23.	Kapurthala, Punjab	5.0 MW
24.	Ferozpur, Punjab	2.0 MW
25.	Amritsar, Punjab	2.0 MW
26	Birchgunj Military Station, Andaman & Nocobar Islands	1.0 MW
27	Camicobar Military Station, Andaman & Nocobar Islands	1.0 MW
28	Campbell Bay Military Station, Andaman & Nocobar Islands	1.0 MW
29	Kamorta Military Station, Andaman & Nocobar Islands	1.0 MW
30	Shibpur Military Station, Andaman & Nocobar Islands	1.0 MW
31	Detailed Project Report to Kandla Port Trust	14 MW
32	Advisory Services to National Fisheries Development Board (NFDB) for vetting of a proposal on Demonstration of Wind and Solar hybrid Chilling Unit and Solar Powered de-hydrator for fish	-
33	Advisory Services to National Seeds Corporation Limited for setting up of Solar PV Plants in their unused lands.	-



Quality Verification Services of Photovoltaic Power Plants

NISE initiated Quality verification services for photovoltaic power plants to meet the quality standards and analyse the technical specifications of solar PV plants to assure the customers. The proposed specialized services are designed and offered for various stakeholders, facility owners, investors, financial institutions, banks, EPC contractors, project developers, service providers and insurance firms interested in assessing the operational condition of a given solar PV installation or portfolio

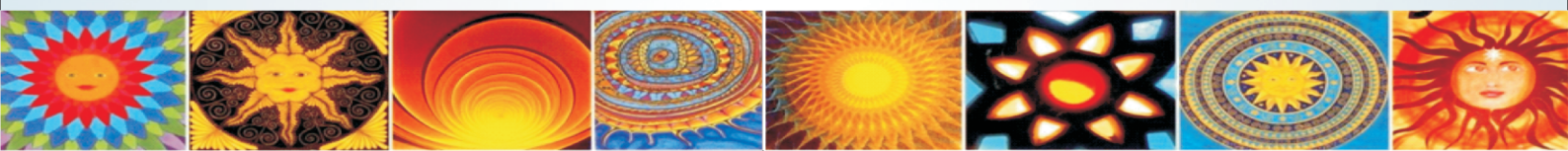


Customer benefits:

- Maximisation of the energy output/performance ratio in the long term
- Minimisation of risks of failure
- Plant performance verification
- Post-inspection of PV plants
- Establishment of investment safety and Bankability
- Protection of return on investment in the PV system
- Recommendations for zero-defect planning and installation of future PV systems.
- Improvements of operation and maintenance procedures.
- Facilitated provision of evidence in case of damage

Services shall verify:

- The installation of plant is according to the precise specifications and compliance with the national/ international standards
- Photovoltaic power plant is operating safely and according to the relevant guidelines and standards
- The verification will include SOLAR Parks, Roof top, off grid and other customized systems inspection
- The verification inspection will include installation components, sizing of components, quality & rating of all the components such as inverters, installation practice and safety concerns
- Testing and performance measurement of PV module/array and BOS etc



The verification report will includes:

- Certificate of verification
- Inspection report
- PV array test report and suggestions to improve the PV power plant quality wherever necessary

As per following standards:

- IEC 62446,
- IEC 62124,
- IEC 60364 (all protective measure parts) - Low-voltage electrical installations
- IEC 60364-6 - Low-voltage electrical installation – Part 6: Verification
- IEC60364 – 7 – 712 - Electrical installations of buildings – Requirements for special installations or locations – Solar Photovoltaic (PV) power supply systems.

13. NISE Training earnings during FY 2015-16

The following are the earnings of NISE on account of Training during FY 2015-16.

S No	Name of Programs	Amount (Rs Lakhs)
01.	Internal Training Programs	19.22
02.	International Training Programs	16.40
03.	Suryamitra Training Programs	21.59
	Total	**57.21**

14. Technology Business Incubation (TBI)

NISE is in the process of setting up of Technology Business Incubation (TBI) Centre at its campus. NISE TBI shall be a separate entity which shall be located within NISE campus. NISE TBI shall provide space, expert guidance, allow lab facilities of NISE and assist in obtaining financial support for the aspirants/ people coming up with innovative ideas in the field of renewable energy technologies with a major focus in solar energy. Specific infrastructure is being created for this purpose at NISE. NISE proposes to seek financial assistance from Department of Science and Technology (DST), Govt of India for setting up of NISE TBI

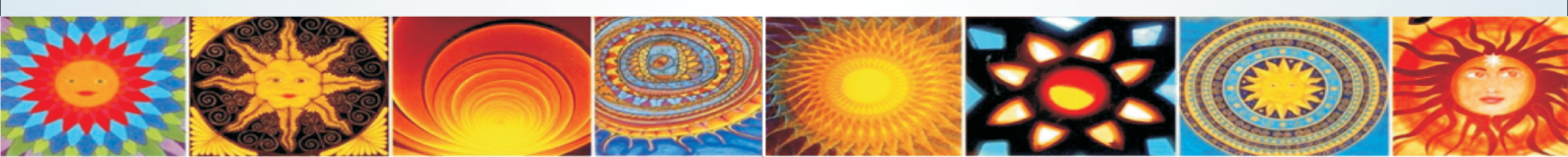
15. Infrastructure for skill development Division – set up of laboratories

Skill development division has created three state of the art laboratories for participants of skill development programs

a) Solar design laboratory with exclusive high end software tools like PV Syst, PV*Sol, T Sol, Genius etc. with supporting latest hardware.

b) Solar electronics laboratory for experiments in grid-tied PV, MW range power plants, 1MW solar Thermal simulation, inverter designs & configurations etc.

c) Exclusive Renewable Energy laboratory with state of the art experimental set ups on Solar PV, Solar Thermal, Bio Mass, Wind etc.





Solar PV Electronics Laboratory

Chapter-4

Hydrogen Energy & Fuel cell Division

4.1 Introduction

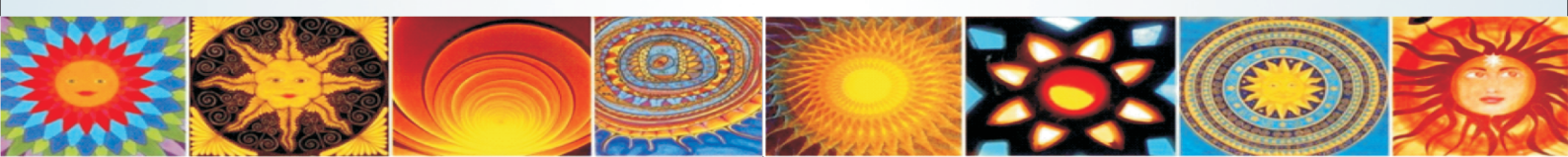
Growing GHG emissions and their impact on the environment emphasizes the need of renewable sources of energy. Keeping this in view, the current project envisages powering the motor-vehicles on a completely green fuel. The project aims to produce hydrogen by the process of water electrolysis using solar energy. India being a tropical country receives enormous amount of solar energy.

As hydrogen appears to be a potential solution for a carbon-free society, its production plays a critical role in showing how well it fulfills the criteria of being environmentally benign and sustainable. Hydrogen can be produced from a number of sources, such as water, hydrocarbon fuels, biomass, hydrogen sulfide, boron hydrides, and chemical elements with hydrogen. Because hydrogen is not available anywhere as a separate element, it needs to be separated from the aforementioned sources, for which energy is necessary to do this disassociation. The forms of energy that can drive a hydrogen production process can be classified in four categories: thermal, electrical, photonic, and biochemical energy and from Primary Energy Source (fossil, nuclear, and renewable). The project endeavors to use this huge potential in establishing a solar-hydrogen fuelling system

The objective of the Project is to Generate, Store and Utilize Hydrogen as a fuel for vehicles and for stationary power generation. A 120 kWp Roof Top Solar PV Power Plant installed in the Campus is providing power for electrolysis of water, where the molecule of water splits into Hydrogen and Oxygen. The Hydrogen is further pressurized up to 550 bars and stored in gaseous form in Storage tubes. The stored Hydrogen can be used as a fuel in vehicles or as a source of stationary power generation.

4.2 Project Background and Summary:

The Hydrogen and Fuel Cell Division is working on the R & D project entitled, “Demonstration & Performance Evaluation of various technologies of Hydrogen Energy at the National Institute of Solar Energy, Gwal Pahari, Gurgaon, Haryana.” sanctioned by Ministry of New and Renewable Energy. The Project intends to meet the objectives of operation and maintenance of the existing Hydrogen Production and Utilization Facility installed and commissioned in NISE for research and development and demonstration, and evaluation of hydrogen dual fuel vehicles and operation and performance evaluation of fuel cell systems.



4.2.1 Objectives and the Approved Output of the Project

The main objectives of the project are as follows:

a. Operation and Maintenance of Solar Hydrogen facility at NISE, Gwal Pahari.
b. To demonstrate hydrogen / hydrogen blended fueled vehicles (3- wheelers & 4-wheelers) developed under the R&D projects supported by the Ministry.
c. To operate / demonstrate fuel cell based systems for stationary power generation.
d. To organize training programme on different aspects of Hydrogen Energy and Fuel Cell Technologies.

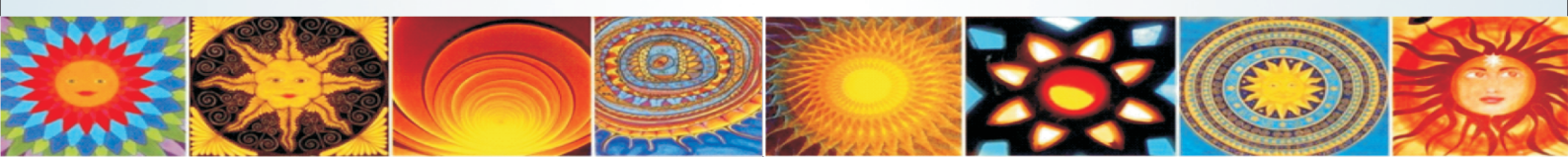
Approved Output of the Project

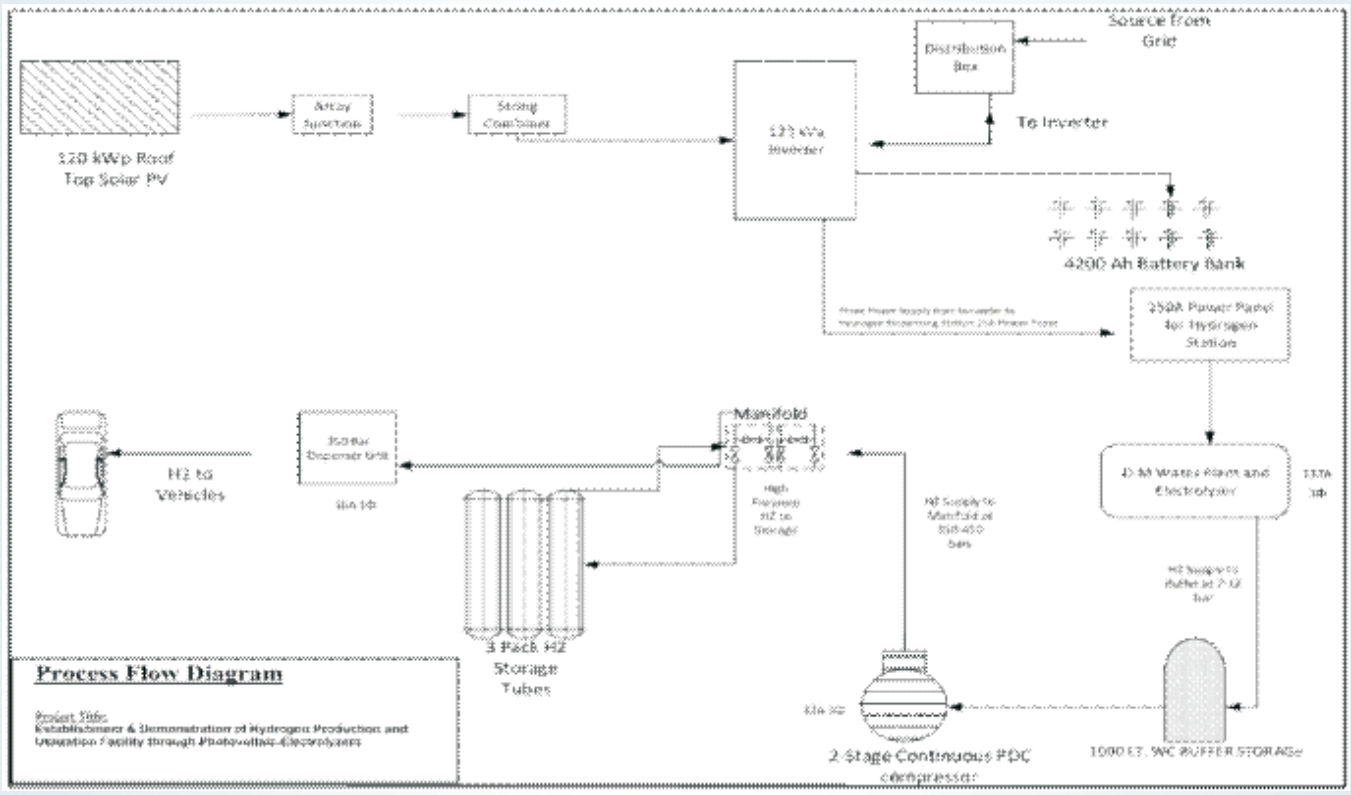
a. Production of Hydrogen through solar PV technology.
b. Demonstration of different Hydrogen fueled Vehicles and Fuel cells.
c. Awareness and training of Hydrogen Technology and its application.
d. Technology validation and completion of trial runs of Hydrogen based vehicles and Proton Exchange Membrane Fuel Cells.
e. Testing/demonstration of continuous operation of fuel cell system for one thousand hours

4.2.2 System specifications:

The facility consists of a 120 kW rooftop solar power plant, 125kVa inverter, a Hydrogen production system comprising of a 5 Nm3/hr Electrolyser, a buffer and compressor system. For the operation purpose of Hydrogen Facility the necessary approval from Petroleum, Explosives and Safety Organizations, Nagpur were obtained in July 2015. Thereafter, facility is being operated continuously for generation, storage and dispensing of Hydrogen. In addition to this other operational issues are being identified. Regular troubleshooting is done for maintenance and continuous operation of the Facility.
Under this project facility, following are the major sub systems:

1. 120 kWp SPV Power plant with Battery bank 4200 Ah, 240V,
2. 5 Nm3/hr Electrolyser (capable of producing 10.5 kg for 24h operation at full capacity)
3. Compressor (delivery pressure of 350-550 bar)
4. Buffer (1000 liter capacity)
5. High pressure storage tanks (up to 550 bar max pressure)
6. Dispenser (1kg/min at 350 bar)
7. Purity of Hydrogen: 99.999%







Hydrogen Production, Storage and Dispensing Facility at NISE



Hydrogen Storage and Compression System



120 kWp Rooftop Solar Pv System



Hydrogen Fueled vehicle



1 kw Fuel Cell System

4.3 Project Activities under taken during the year

i. Approval from Petroleum and Explosives Safety Organization:

NISE had approached Petroleum and Explosives Safety Organization (PESO) to obtain approval for establishing and operating the Hydrogen dispensing station on the Campus and running the vehicles on dual fuel including Hydrogen. PESO approval for the dispensing facility at NSIE was received on 23rd June 2015 and since then the facility is being operated as a hydrogen production and storage facility. As of now a storage pressure up to 400 bar has been achieved.

The training on operation and safe handling of Hydrogen Facility was provided to the project members by M/s Air Products.

Approval for running four Hybrid vehicles developed by Mahindra & Mahindra on hydrogen and diesel was obtained from PESO and Ministry of Road Transport and Highways. Further regular filling and trials are being carried out for performance evaluation of Dual-Fuel Vehicles

ii. <u>Operation and Maintenance of Solar-Hydrogen Facility:</u>

The Hydrogen Dispensing Station at NISE is being operated using the power generated by the 120kWp roof top SPV power plant. The generated hydrogen is used as a fuel for Dual-Fuel vehicles provided by Mahindra & Mahindra Ltd. The Hydrogen produced is of fuel cell grade and therefore, it can be used for fuel cell application as well.

78 kgs of Hydrogen has been produced so far and stored at a pressure of 350 bar and above in High Pressure Storage Tubes. This hydrogen gas has been utilized for performance evaluation of Dual Fuel Vehicle and other related activities like testing, and other calibration purposes. Maximum Pressure up to 550 bar has been achieved so far in the high pressure storage tubes as given below:

S.No.	Description	Details
1.	Hydrogen Production	5 Nm^3/hr
2.	Hydrogen Production in kgs.	78 kgs
3.	Maximum Pressure (High Pressure Storage Tubes)	550 Bar , 380 Bars achieved
4.	Purity	99.999%

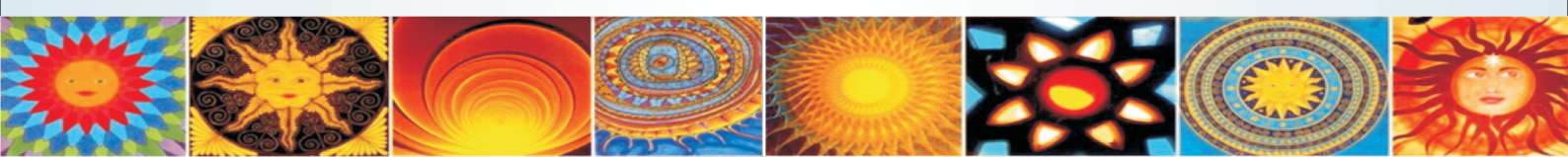
iii. Trial Run of Dual Fuel Hydrogen Vehicles :

Trial run for performance evaluation of Dual-Fuel Vehicle is currently under progress and regular filling of Hydrogen Gas is provided to 2 nos of Mahindra Scorpio and 3 nos of Mahindra Pickup vehicles

4.4 Development and Establishment of Fuel Cell Laboratory :

A fuel cell is a device that converts the chemical energy from a fuel into electricity through a chemical reaction. Unlike batteries fuel cell require a continuous source of fuel and oxygen or air to sustain the chemical reaction. Fuel cells can produce electricity uninterruptedly for as long as these inputs are provided. There are many types of fuel cells, but they all consist of an anode, a cathode, and an electrolyte that allow protons (positively charged hydrogen ions) to move between the two sides of the fuel cell. The anode and cathode contain catalysts that cause the fuel to undergo oxidation reactions that generate positive hydrogen ions and electrons. The hydrogen ions are drawn through the electrolyte after the reaction. At the same time, electrons are drawn from the anode to the cathode through an external circuit, producing direct current electricity. At the cathode, hydrogen ions, electrons, and oxygen react to form water.

This classification determines the kind of electro-chemical reactions that take place in the cell, the kind of catalysts required, the temperature range in which the cell operates, the fuel required, and other factors. These characteristics, in turn, affect the applications for which these cells are most suitable. There are several types of fuel cells currently under development, each with its own advantages, limitations, and potential applications. Depending on the kind of electrolyte, the fuel cells can be primarily classified into the following-



1. Direct Alcohol (Methanol/Ethanol) Fuel Cells
2. Polymer Electrolyte Membrane Fuel Cells
3. Alkaline Fuel Cells
4. Phosphoric Acid Fuel Cells
5. Molten Carbon Fuel Cells
6. Solid oxide Fuel Cells
7. Microbial Fuel Cells

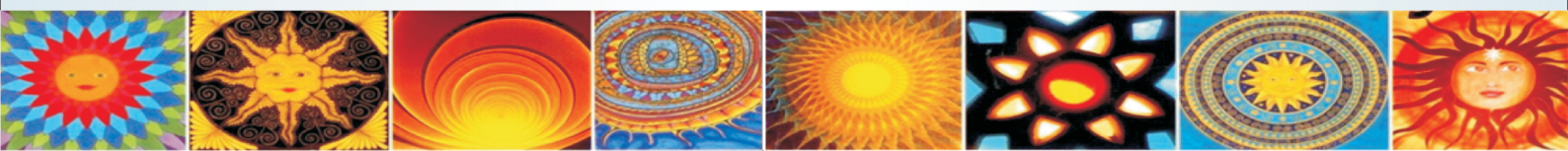
Fuel cells are used for primary and backup power for commercial, industrial and residential buildings and in remote or inaccessible areas. They are also used to power fuel-cell vehicles, including forklifts, automobiles, buses, boats, motorcycles. Fuel cells have the potential to replace the internal-combustion engine in vehicles and provide power in stationary and portable power applications because they are energy-efficient, clean, and fuel-flexible.

The Fuel Cell Testing Laboratory at NISE aims to carry research & development, testing of various types of Fuel Cells, monitoring and performance evaluation of the Fuel Cell, components & systems at different capacities, comparison of different kind of fuel cells in India and their techno-economic viability, development of test protocols for various type of Fuel Cells and development of standards for Indian conditions. The Centre will be a full-fledged Research and Technology facility with wide ranging laboratory and workshop facilities for research and prototype testing. A new lab has been constructed with Aluminum and glass. Fuel cells of different capacities have been received and under installation. A proper fitting for Hydrogen gas pipelines with leak detectors is under process. Also, DC-AC has been procured for the Hydrogen Fuel Cells. Procurement of other equipments for Hydrogen Fuel Cell system and its applications are under process.

Also, DC-AC has been procured for the Hydrogen Fuel Cells. Procurement of other equipments for Hydrogen Fuel Cell system and its applications are under process.

For the development of Fuel Cell Laboratory, various laboratories such as Fuel Cell Laboratory, IIT-Delhi, International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), IIT-M, Chennai, Central Electro Research Institute, CSIR, Chennai, Mahindra & Mahindra, Chennai were visited to understand set up of Fuel Cell Laboratory. Discussions were held with the experts and team working on Fuel Cells

Laboratories Visited	Research Areas
Fuel cell Laboratory, IIT-Delhi	Research and development on Direct Ethanol Fuel Cells, Direct Hydrogen Fuel Cells and Solid Oxide Fuel Cells which includes development, characterization and testing of materials related to electrodes, catalyst and membranes.
International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), IIT-M, Chennai	Developed 20kW Hydrogen Polymer Electrolyte Membrane Fuel Cell Stack, Project completed with Rewa and Mahindra & Mahindra. Working on the Research & Development of engine using Hydrogen as fuel.
Central Electro Research Institute, CSIR, Chennai	Developed 15kW Hydrogen Polymer Electrolyte Membrane Fuel Cell Stack, Working with Reliance Group. Research & Development of various materials for different kind of Fuel cells
Mahindra & Mahindra, Chennai	Hydrogen mini buses have been developed and ready for demonstration. They are also developing Fuel Cell car using 15 kW HPEMFC.
Banaras Hindu University, Varanasi-(Proposed)	Three wheelers with Metal hydride storage.



Based on the knowledge gained from the above visits a new lab with air conditioning has been constructed with Aluminium and glass Ceilings

Fuel Cells of 1kW and 2kW have been procured from M/s Horizon Indian. The Fittings of Fuel cell with loads and supply arrangements of Gases to Fuel cell Cylinders is under process and is expected to complete soon



Activities to be undertaken:

i. Performance analysis of Fuel cell Systems.

- Installation of the Fuel cells is in progress.
- Development of Fuel Cell Laboratory with all the installation is likely to complete by end of June 2016 along with the pipes and tubing arrangements which are to be made for supply of hydrogen to the fuel cell systems.
- Data Loggers are to be procured for the purpose of data recording and tender process for its procurement is in Process and the procurement is expected to be completed by end of June, 2016.
- Thereafter the Testing of various Fuel Cell Systems will be initiatedt.

ii. Continuing the Trial Runs of Hydrogen Fuel Hybrid vehicles.

The trial runs of Hydrogen Fuel Hybrid Vehicle which as of now have completed a few thousand kilometers is expected to continue with a rapid pace for next six months.

iii. Emission testing for Hydrogen Fuel Hybrid Vehicle for performance evaluation Purpose. The vehicle and engine shall be tested for hydrocarbon, carbon monoxide, carbon dioxide, oxides of nitrogen and particulates. Measurement of aldehydes, ketones, SO2, NMHC, and CH4 is also to be taken up.

iv. Performance analysis of Vehicle: A third party assessment shall be conducted for analysis and performance evaluation of vehicle considering below mentioned parameters:

- Power and Mechanical Efficiency.
- Mean Effective Pressure and Torque.
- Specific Output.
- Volumetric Efficiency.
- Fuel-air Ratio.
- Specific Fuel Consumption.
- Thermal Efficiency and Heat Balance.
- Specific Weight.

Chapter-5

R&D Co-ordination Cell

Introduction

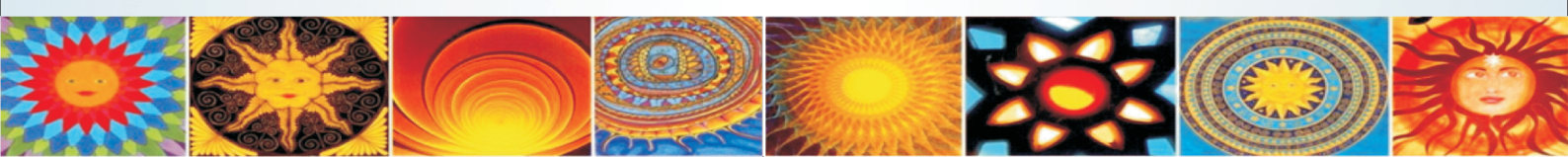
One of the important activities at the NISE is to be associated with R&D in the field of Solar Energy (SE) applications which include those in the areas of solar photovoltaics (SPV) and solar thermal (ST). NISE has been doing so at present by providing active support to the MNRE's R&D initiatives. The Institute has been involved in scrutinizing the R&D proposals submitted to the Ministry at the initial stage, getting the experts' comments, arranging RDPAC and RDSPAC meetings and recommending proposals to the MNRE for sanction. Furthermore, it has also been responsible for monitoring the on-going R&D projects through expert visits, organising reviews, suggesting mid-course corrections, and monitoring and verifying claims as an independent, un-biased agency. The NISE is involved at all stages of nucleation, growth, correction and logical conclusion of the R&D projects. The NISE is also involved in a few important, thrust area projects where direct participation is envisaged to help achieve the desired goals. NISE is also executing externally aided, large consortium projects funded by the DST and other ministries on specific topics where there is a requirement or direct intervention is sought.

The responsibilities of R&D coordination and monitoring lies with the R&D Co-ordination Cell or simply R&D Cell which comprises two departments, namely, a) solar photovoltaic (PV) department and b) solar thermal (ST) department

Project Monitoring for on-going projects

In the area of PV, there are 13 projects in the category of on-going or recently completed projects. On-site monitoring has recently been carried out for six of these on-going projects as per the schedule below:

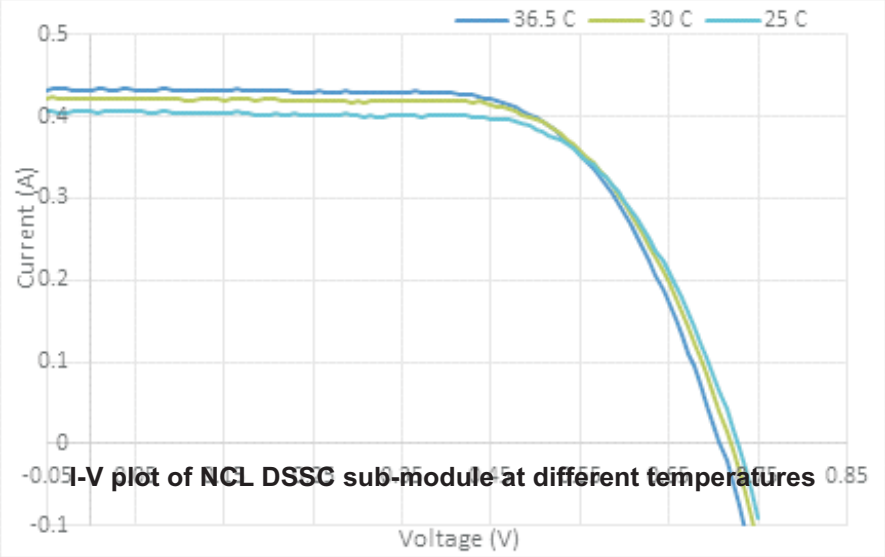
i) Power electronics for PV at Jamia Milia Islamia, Delhi on 5.8.2015
ii) Solution based CZTS solar cells at PDPU, Gandhinagar on 24.8.2015
iii) Floating PV power plant at AR-IGNOU Community College, Kolkata in October 2015
iv) NCPRE Phase 1 project at IIT Bombay on 14.12.2015
v) DSSC/ Q-DSSC solar cell project at NCL, Pune on 22.12.2015 and
vi) TF solar cells and PV systems at IIEST, Shibpur, Howrah on 20.02.2016.



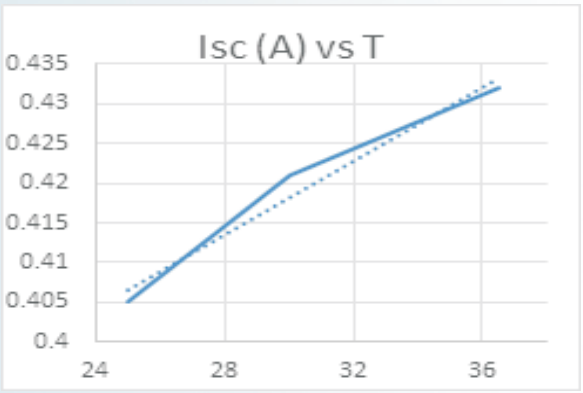
Monitoring is also planned soon for the other six projects. The final project completion report has been sent by NCPRE Phase 1 project for acceptance.

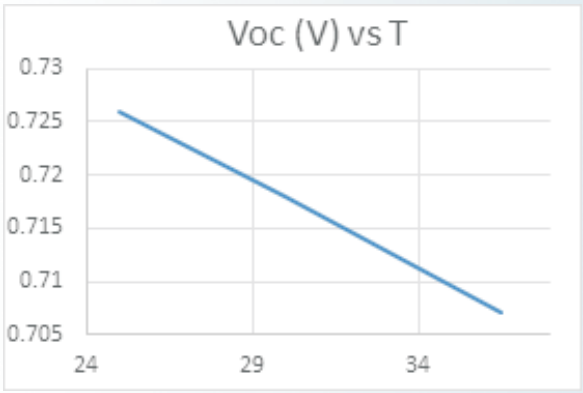
The reports of the Project Monitoring Committees (PMC) have been sent to the Ministry with specific recommendations. For example, the PMC found the progress of the project at PDPU, Gandhinagar, un-satisfactory; therefore, it has been recommended for being short-closed by the recently held RDSPAC. Achievements at the other projects have been satisfactory. Notably, the project at NCL, Pune/ IICT Hyderabad project on DSSC solar cells has come up with a 29 sq. cm sub-module which was measured to be ~ 7 % efficient (on active area basis) when measured at NISE. Some of the measurements made on this cell at NISE are shown in Fig. 5.1. For the cells developed at NCPRE, IIT Bombay, third party verification of the claim has been done by NISE with the help of measurements at CEL. For the future cell related developments, the claims can be validated independently at NISE as the cell measurement facility at NISE is presently undergoing major up gradation. Apart from this, all the remaining projects are evaluated at NISE based on the mid-year status reports received at the end of Sept, 2015 and the reports forwarded to the Ministry

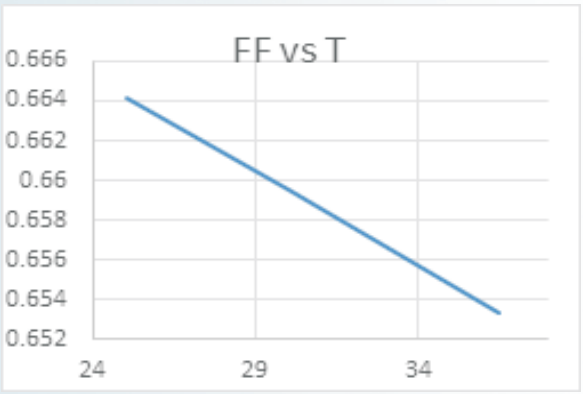
Out of the 13 recently completed/on-going R&D projects, 2 projects have recently been completed. These are NCPRE Phase 1 project at IIT Bombay and QD solar cell project at Jain University, Bangalore. The PI of the project at IIEST has requested for an extension period of 6 months without an escalation of the outlay. The project on development of high efficiency CIGS solar cells, taken up at Moser Baer, has been short closed as the implementing agency has expressed its inability to continue with the project as it requires further investment by the company and the prospects of thin film solar cells does not look very bright as of now. Accordingly, the T&C equipment that was brought from the MNRE funds, has been asked to be shifted to NISE. As per this directive from the MNRE, NISE is setting up a semi-clean room to house these two pieces of equipment namely XRD and SEM with EDAX facility

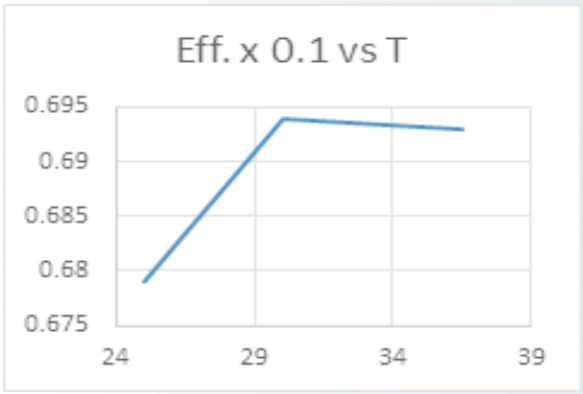


I-V plot of NCL DSSC sub-module at different temperatures









Variation with temperature of electrical parameters of NCL DSSC sub-module

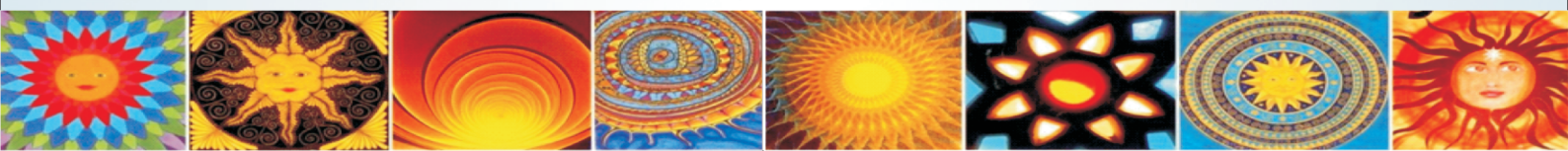
Temp coeff. of Isc :	0.0023 A / deg C or	0.568 %/ deg C
Temp coeff. of Voc :	-1.65 mV/deg C	-0.22 % / deg C
Temp coeff. of FF :	-0.009 / deg C	-1.35 % / deg C

Conclusion: Device efficiency goes through a peak at around 30 Deg C

Fig.5.1 Measurements of a 29 cm2 NCL DSSC sub-module

Evaluation of new project proposals

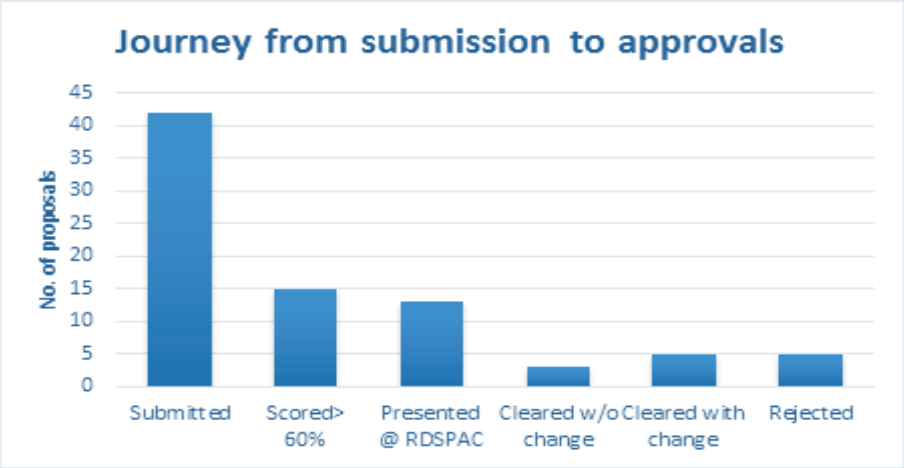
Since September 2015, two lots of new project proposals have been received in PV for evaluation and further processing. There were 21 project proposals in the first lot of which two high value project proposals mooted by NPL and BHEL were evaluated by experts and taken up at the RDPAC meeting held in November 2015. The rest of the PV project proposals that are equally divided into PV cells & materials and PV systems & applications with almost equal number of proposals belonging to each category, have been scrutinized at NISE and 8 projects have been held back for future consideration. All the other projects have been sent to selected panels of experts for evaluation. These projects are also being evaluated at NISE. Out of the total of 34 external reports expected, already 23 have been received and follow-up is in progress for the other 11 reports. These would be considered in the next meeting of the RDSPAC. The NISE has also re-visited the existing panel of experts and made a few changes as per the need. Meanwhile, the NCPRE Phase II project also came up for discussion in RDPAC meeting and was given an in-principle go-ahead. NISE also participated actively in finalization of the deliverables of the Phase II of the project at IIT Bombay.



For the next lot of projects received in February/ March 2016, a thorough preliminary scrutiny of the project proposals was carried out with involvement of officials from MNRE Solar R&D Division, external experts and NISE personnel. A number of project proposals were transferred to the ST group and a number of others considered as rejects. In total, only four projects from solar cell and materials category and 14 projects from the PV systems and applications category have been cleared by the screening committee for further processing. These would now be sent to experts for their comments.

RDPAC and RDSPAC meetings

The PV part of the RDPAC meeting held on 26.11.2015 and the RDSPAC meeting in PV, held on 8th March 2016 were completely organized by NISE. This included collecting evaluation reports from the external experts, sending these to the MNRE, deciding on the proposals that need to be called for presentation based on their average score, preparing the booklet containing the meeting agenda, paying TA/DA to the external experts and working with MNRE and the members to finalise the MoM. A good amount of sincere follow-up from NISE resulted in evaluation reports from the external experts to the extent of 94 % for the Lot I and 82 % for the Lot II of proposals received. Together with the view of the expert committee at the time of RDPAC or RDSPAC meetings, this ensures proper assessment of the project proposals. The figure below shows a typical travel of a lot of project proposals from the stage of submission to the stage of approval at the RDSPAC meeting.

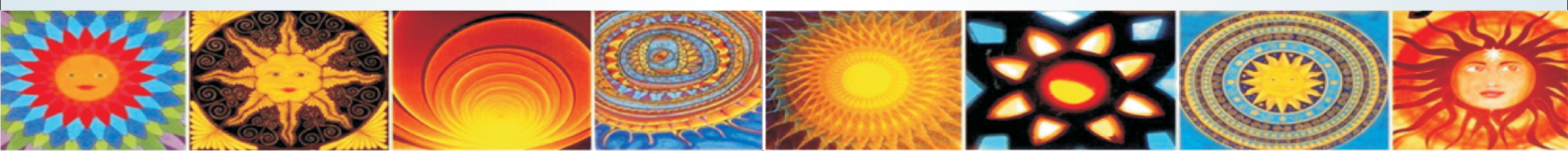


Establishment of new materials characterization laboratory, up-gradation of the cell testing facility and new project with BHEL

A new facility for electroluminescence (EL) testing of PV modules has been established at NISE during the reporting period. It involved procurement of the EL testing equipment, creation of a suitable space in the workshop at NISE to house the equipment, commissioning it and running it regularly to test all different kinds of modules.

Apart from this, a semi-clean room space is also being created at NISE to house the two pieces of test and characterization that NISE would be receiving from M/s Moser Baer at the short-closure of the MNRE funded project on CIGS solar cell development.

As a third activity, the solar cell test facility at NISE is being up-graded by replacing the old Kepco power supply with a new one and also designing a four point contact probe for the front of large area (upto 6 sq. inch) solar cell.



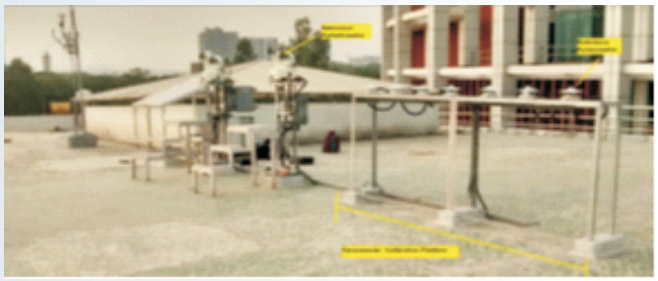
For the BHEL-NISE joint project on high efficiency PERC solar cells, both the agencies have put together in place technically competent teams and are looking at entering into an MOU which would further facilitate joint working on the ambitious project

Project evaluation and monitoring of on-going projects in Solar Thermal

In solar thermal, out of eight ongoing R&D projects two projects have been completed during the year. In one of the completed projects entitled "Development of Modular Central Receiver Concentrated Solar Power Plant for Decentralized Power Generation", design and fabrication of prototype receiver have been completed and currently being tested for its performance at NISE. Another major completed project is on solar thermal power entitled "Development of a Megawatt Scale National Solar Thermal Power Testing Simulation and Research Facility", which has been installed and tested for its functionality at NISE by IIT, Bombay.

Under Solar Radiation Resource Assessment (SRRA), a Ministry of New and Renewable Energy (MNRE) flagship program, 111 SRRA stations have been put up which is the world's largest network of ground measurement solar radiation resource assessment stations distributed all over the country. A Calibration Laboratory for calibrating the SRRA instruments installed in the field has been set up.

The laboratory follows all the International standard procedures for calibration of sensors as specified by WMO and also by Regional Radiation Centre i.e. IMD Pune. This project has been implemented by Solar Energy Corporation of India (SECI) in collaboration with NISE, funded by MNRE.



Solar Radiation Calibration Laboratory (SRCL) facility at NISE



Solar Calorimeter

Under a project on Solar Passive Architecture and green building technologies, the CEPT University has established capabilities to characterize thermo-physical-optical properties of building materials. It has developed a database of material ranging from generic building materials such as stone, bricks, roofing tiles to industrially produced materials such as XPS, PU, EPS, glass, glass coatings. A State-of-art facilities is set up at CEPT campus working continuously with industry and research scholars and have establish robust database of generic building materials. This online tool has been tested and is available on website.

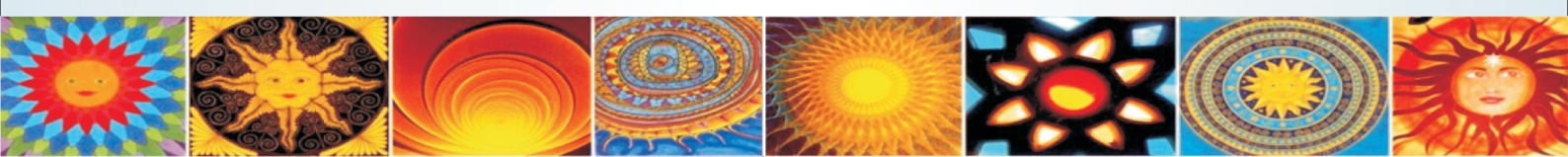
Under a project on "Establishment of Centre of Excellence in Solar Thermal Research and Development at IIT Jodhpur", several laboratories/facilities leading to state-of-the-art research are being set-up. This covers solar resource, optical design, material characterization, high-temperature solar thermal and smart grid.

A grid-interfaced DC grid is developed using the installed 100 kWp solar photovoltaic plant at IIT Jodhpur. The developed DC-DC boost converter allows interface of the PV with DC grid. The designed system is being tested using an installed real time digital simulator (RTDS). The aim of the activities is integration of various renewable energy sources, like, solar-wind.

In addition, a schedule has been prepared for on-site monitoring of the on-going projects. Under this schedule, on-site monitoring has recently been carried out for four on-going projects at IIT, Jodhpur; CEPT University, Ahmedabad and RGPV, Bhopal and RKDF, Bhopal.

As a part of Institute outreach programme, an annual review cum state-of-the-art series has been planned with an objective to provide quality literature in the field of solar energy to all the stakeholders. The first volume in this series entitled "Advances in Solar Energy Science and Engineering" edited by National Institute of Solar Energy (NISE) has been published in 2015. Another volume (Vol.-2) of the series with the thrust on Solar Thermal Energy has also been published in the year 2016.

The Scope of this serial publication (volumes) is broad and encompasses recent developments in the field and is addressed to serious students, researchers, policy analysts and energy planners seeking a fuller understanding of technical factors underlying Solar Energy Development and commercialisation.



VBR & Associates
Chartered Accountants

Independent Auditor's Report

Report on the Financial Statement

We have audited the accompanying financial statements of **NATIONAL INSTITUTE OF SOLAR ENERGY** ("the Institute"), which comprise the Balance Sheet as at 31 March 2016, the Statement of Income & Expenditure and the Receipts & Payments Account for the year then ended, and a summary of significant accounting policies and other explanatory information.

Management's Responsibility for the Financial Statement

The Management is responsible for the preparation of these financial statements that give a true and fair view of the financial position and financial performance of the Institute in accordance with the accounting principles generally accepted in India. This responsibility also includes the maintenance of adequate accounting records in accordance with the provision of the Act for safeguarding of the assets of the Institute and for preventing and detecting the frauds and other irregularities; selection and application of appropriate accounting policies; making judgments and estimates that are reasonable and prudent; and design, implementation and maintenance of internal financial control, that were operating effectively for ensuring the accuracy and completeness of the accounting records, relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

Our responsibility is to express an opinion on these financial statements based on our audit.

We conducted our audit in accordance with the Standards on Auditing issued by ICAI. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal financial control relevant to the Institute's preparation of the financial statements that give true and fair view in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by Institute's Directors, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion on the financial statements.

91-11-43022799
91-9811300570
www.vbrindia.com

611, Roots Tower, Plot No.7
District Centre, Laxmi Nagar, Delhi-110092
email: binit@vbrindia.com

Report on the other Legal and regulatory Requirements

1. The GFR Rules 2005 in several cases during the year relating to the purchases made and the work contracts awarded by the Institute are not complied strictly. Detailed observations in this regard have been provided to the management for compliance.

2. The Internal Control system of the Institute needs to be strengthened. During the course of our audit, administrative and financial lapses were found, details of some of the observations are given in the **Annexure A** attached. The details of remaining observations were provided to the management separately which they have noted for future compliance and kept on record along with their comments.

3. We report that:

   a) we have sought and obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit;

   b) in our opinion proper books of account as required by law have been kept by the Institute so far as appears from our examination of those books.

   c) the Balance Sheet, the Statement of Income & Expenditure, and Receipt & Payment Account dealt with by this Report are in agreement with the books of account.

   d) In our opinion, the Balance Sheet & Income & Expenditure dealt with by this report complies with the Accounting Standards issued by the Institute of Chartered Accountants of India.

Opinion

In our opinion and to the best of our information and according to the explanations given to us, the aforesaid financial statements, give the information required by the Act in the manner so required and give a true and fair view in conformity with the accounting principles generally accepted in India:

   a) in the case of the Balance Sheet, of the state of affairs of the Institute as at March 31, 2016;

   b) in the case of the Statement of Income & Expenditure, of the **excess of income over expenditure** for the year ended on that date;

For **VBR & Associates**
Chartered Accountants
FRN 013174N

(Binit K. Agrawal)
(Partner)
Membership No. 088042

Place: Delhi
Date : December 15, 2016

Annexure A

Administrative Lapses

- Performance guarantee against the contract was not taken in any case.
- The Fixed assets register is not maintained properly.

Financial Lapses

- In some of the cases EMD received in the Form of DD was not deposited in bank account. There is loss of interest on this amount. Also DD becomes stale after three months hence such cases where DD for EMD is lying in the file, are at par with the cases where the stipulated EMD is not received.
- In some of the cases EMD was demanded and accepted below the required amount, violating the GFR Rules.
- TDS was not deducted in some cases (details provided separately) according to the Income Tax provisions.
- On non-completion of contract within stipulated time, penalty was not initiated on the Contractor. Some of the contractors are;
  1. National Building Construction Corporation
  2. TATA Power Solar System Limited
  3. Gayathiri Computer Solutions
- Tender Fee was not charged in all the tenders issued.

For **VBR & Associates**
Chartered Accountants
FRN 013174N

(Binit K. Agrawal)
(Partner)
Membership No. 088042

Place: Delhi
Date : December 15, 2016

NATIONAL INSTITUTE OF SOLAR ENERGY

(An Autonomus Institute of Ministry of New & Renewable Energy ,Govt.of India)
Gurgoan-Faridabad Road, Gwalpahari, Gurgaon, Haryana-122003

BALANCE SHEET AS AT 31ST MARCH 2016

Amount in ₹

CORPUS/CAPITAL FUND AND LIABILITIES	SCHEDULE	AS AT MARCH 31, 2016		AS AT MARCH 31, 2015	
Corpus/Capital Asset Fund	1				
Gross Corpus/ Capital Fund		3360,73,774		2003,29,683	
Less : Accumulated Depreciation		58,11,440		9,19,380	
Net Corpus/ Capital Fund			3302,62,333		1994,10,303
Current Liabilities & Provisions	2		1400,93,797		1962,72,371
Total			**4703,56,130**		**3956,82,674**

ASSETS	SCHEDULE	AS AT MARCH 31, 2016		AS AT MARCH 31, 2015	
Fixed Assets	3				
Gross Block		365,40,213		72,86,913	
Less : Accumulated Depreciation		58,11,440		9,19,380	
Net Block			307,28,773		63,67,533
Current Assets, Loans & Advances	4		4396,27,358		3893,08,587
Misc. Expenses to the extent not written off			-		6,554
Total			**4703,56,130**		**3956,82,674**
SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO ACCOUNTS	11				

As per our Audit Report of even date
For VBR & Associates
Chartered Accountants
(FRN-013174N)

(Binit K Agrawal)
Partner
M. No.088042

Place: Delhi
Dated: December 15, 2016

For NATIONAL INSTITUTE OF SOLAR ENERGY

Dr. Rajesh Kumar
(Dy. Director General)

Er. S. K. Singh
(Director General)

NATIONAL INSTITUTE OF SOLAR ENERGY

(An Autonomus Institute of Ministry of New & Renewable Energy ,Govt.of India)

Gurgoan-Faridabad Road, Gwalpahari, Gurgaon, Haryana-122003

Amount in ₹

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED ON 31ST MARCH 2016

PARTICULARS	Schedule	2015-16	2014-15
INCOME			
Receipts from Testing & Operations	5	157,97,413	141,43,673
Grants/Subsidies utilised for Revenue Expenditure	6	1047,71,425	266,87,010
Interest Earned	7	2,34,398	18,27,838
Other Income	7	29,39,975	1,05,900
Depreciation (As per Contra)	3	48,92,060	9,19,380
Total (A)		**1286,35,271**	**436,83,802**
EXPENDITURE			
Establishment Expenses	8	290,37,200	112,24,099
Other Administrative Expenses	9	511,75,479	157,78,360
Operational Expenses	10	292,14,865	38,70,115
Depreciation (As per Contra)	3	48,92,060	9,19,380
Total (B)		**1143,19,605**	**317,91,954**
Net Surplus/(Deficit) for the year		143,15,667	118,91,848
Provision for Taxation		-	32,22,730
Balance being Surplus/(Deficit) for the year transferred to Cospus (A-B)		***143,15,667***	***86,69,118***
SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO ACCOUNTS	11		

As per our Audit Report of even date
For VBR & Associates
Chartered Accountants
(FRN-013174N)

VBR & ASSOCIATES CHARTERED ACCOUNTANTS DELHI FRN-013174N

(Binit K Agrawal)
Partner
M. No.088042

Place: Delhi
Dated: December 15, 2016

For NATIONAL INSTITUTE OF SOLAR ENERGY

Dr. Rajesh Kumar
(Dy. Director General)

Er. S. K. Singh
(Director General)

NATIONAL INSTITUTE OF SOLAR ENERGY

(An Autonomous Institute of Ministry of New & Renewable Energy ,Govt.of India)
Gurgoan-Faridabad Road, Gwalpahari, Gurgaon, Haryana-122003

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2016

Amount in ₹

SCHEDULE 1- CORPUS/ CAPITAL FUND	AS AT MARCH 31, 2016		AS AT MARCH 31, 2015	
General Reserve				
Balance as at the beginning of the year	86,69,118		-	
Add : Excess of income over expenditure during the year	143,15,667		86,69,118	
		229,84,785		86,69,118
Capital Fund				
Grants adjusted against purchase of assets	341,20,865		48,67,566	
Grant utilised for advances given during the year	2789,68,124	3130,88,989	1867,93,000	1916,60,566
Total		**3360,73,774**		**2003,29,683**

SCHEDULE 2- CURRENT LIABILITIES AND PROVISIONS	AS AT MARCH 31, 2016		AS AT MARCH 31, 2015	
Current Liabilities				
Sundry Creditors				
- For goods and services	7,13,846		2,75,803	
- Creditors For Capital Goods	22,86,541	30,00,387	22,86,541	25,62,344
Deposits				
- Earnest Money Deposit	24,97,200		27,200	
- Guest House Security Deposits	30,000			
- Advance Received from Customers	1,81,884	27,09,084	11,74,054	12,01,254
Statutory Liabilities				
- TDS Payable	11,76,512	11,76,512	6,77,501	6,77,501
Other Current Liabilities				
- Salary & Remuneration Payable	-		16,40,288	
- Interest refundable to Ministry	60,35,990		-	
- Advances received against trainning	1,03,300		-	
- Other misc. liabilities	22,992	61,62,282	3,087	16,43,375
Grants Payable to Government of India		1238,22,802		1869,65,167
Provisions				
Provision for Income Tax		32,22,730		32,22,730
Total		**1400,93,797**		**1962,72,371**

SCHEDULE 4- CURRENT ASSETS, LOANS & ADVANCES	AS AT MARCH 31, 2016		AS AT MARCH 31, 2015	
Current Assets				
Cash Balance in hand	3,28,451		34,849	
Balance with Bank :				
-Saving Accounts	1165,97,847	1169,26,298	1821,91,161	1822,26,011
Fixed Deposits under Lien		196,91,225		-
Sundry Debtors		12,78,358		16,44,889
Stamps in Hand		832		-
Loan & Advances & other assets				
Advances and other amounts recoverable in cash or in kind or for value to be received				
- Advances against capital assets	2560,52,885		2019,78,000	
- Advances against trainning programs	308,28,840			
- Other advances	25,65,092		8,15,000	
- Advance to Vendors	49,47,355			
- Recoverable against TDS deduction	-		42,270	
- Recoverable against Training	34,200			
- Recoverable against excess payment	-		1,009	
- Balances in Staff Imprest Accounts	8,23,039	2952,51,411	50,829	2028,87,108
Deposits				
- Security Deposits	1,46,703		10,000	
- Input Credit of Service Tax	25,53,698		3,74,361	
- TDS Recoverable	6,43,713		2,01,099	
- Advance Tax	31,35,120	64,79,234	19,65,120	25,50,580
Total		**4396,27,358**		**3893,08,587**

V&R & ASSOCIATES CHARTERED ACCOUNTANTS

SHEDULES FORMING PART OF INCOME AND EXPENDITURE ACCOUNT AS AT 31ST MARCH 2016

SHEDULE 5- RECEIPTS FROM TESTING AND OPERATIOI	2015-16		2014-15	
Receipts from Testing				
- Testing of Solar Components	121,86,700	121,86,700	95,98,500	95,98,500
Other Operational Receipts				
- Receipts from Trainings and Seminars- Domestic	18,33,213		6,57,981	
- International	16,40,000		23,91,997	
- Consultancy on Techno Economic Feasibility Study	1,37,500	36,10,713	14,95,195	45,45,173
Total		**157,97,413**		**141,43,673**

SCHEDULE 6- GRANTS/SUBSIDIES (Irrevocable Grants & Subsidies Received)	2015-16		2014-15	
Grants Received during the year	1784,00,870		3695,50,549	
Less : Grant Refunded	150,28,386	1633,72,484	30,97,807	3664,52,742
Grant unutilised brought forward from the previous year		1869,65,167		388,60,000
Grant Adjusted towards Revenue Expenditure :				
Current Year Expenditure	1094,27,544		308,72,573	
Less : Expenses adjusted towards current year income	46,56,120	1047,71,425	41,85,564	266,87,010
Less : Grants utilised for purchase of Fixed Assets		292,53,300		48,67,566
Less : Grants utilised for Advances against Capital Expenses		539,11,734		1859,78,000
Less : Grants utilised for Advances against projects		389,78,390		8,15,000
Grants Payable to Government of India		**1238,22,802**		**1869,65,167**

SCHEDULE 7- OTHER INCOME	2015-16		2014-15	
Bank Interest				
- Interest earned on Savings account	2,34,398		67,538	
- Interest earned on Grants account	-	2,34,398	17,60,300	18,27,838
Miscellaneous Income				
- Guest House Charges	12,14,875		1,01,900	
- Administrative Charges	17,25,000			
- Other Income	100	29,39,975	4,000	1,05,900
Total		**31,74,373**		**19,33,738**

SCHEDULE 8- ESTABLISHMENT EXPENSES	2015-16		2014-15	
Consultancy Charges		50,80,572		46,46,254
Project Fellow Stipend		-		17,32,217
Remuneration		219,32,280		43,12,329
Honorarium		-		55,609
Manpower Remuneration (Solar Hydrogen Project)		20,24,348		4,77,690
Total		**290,37,200**		**112,24,099**



SHEDULES FORMING PART OF INCOME AND EXPENDITURE ACCOUNT AS AT 31ST MARCH 2016

SCHEDULE 9- OTHER ADMINISTRATIVE EXPENSES	2015-16	2014-15
Electricity Expenses	80,07,727	37,02,165
Outsourcing Services	142,15,761	23,40,141
Security Services	127,40,130	57,89,675
Audit Fee	92,090	-
Office Expenses	1,55,199	1,94,857
Refreshment/Hospitality/Meetings	9,84,579	3,69,306
Legal & Professional Charges	1,06,478	5,667
Bank Charges	1,01,348	17,640
Discount on Training Fees	30,000	14,106
Horticulture Expenses	5,67,905	11,000
Advertisement Expenses	17,94,592	-
Guest House Expenses	1,35,174	-
Library Books & Periodicals	1,12,918	4,840
Postage & courier	49,320	-
Printing & Stationery	6,60,808	3,33,872
Computer Software and accessories Expenses	3,96,270	54,000
Repairs & Maintenance Expenses	75,21,696	9,65,911
Expenses written off	6,554	-
Telephone Expenses	7,84,937	5,35,001
Vehicle Running & Maintenance	3,71,869	3,37,521
Tour / Travel & Transport	23,40,126	11,02,707
Total	**511,75,479**	**157,78,360**

SCHEDULE 10- OPERATIONAL EXPENSES	2015-16	2014-15
All India SPV Module Survey-II (2014)	-	2,85,600
SERIIUS Project Expenses	7,04,558	1,23,172
Short Film on NISE THE SHINING STAR	-	5,60,000
Expenses on Skill Development Programs	128,78,378	-
Thermal Power Project Expenses	15,66,100	-
R&D Cell Expenses	8,75,410	1,94,730
Testing/Accredation Charges	-	97,238
Seminars/Conferences/Training Programmes	69,21,422	21,47,371
Hydrogen Project Exp.	12,81,550	33,456
Exhibition/ Events Expenses	43,34,032	-
Consumables/ Laboratory/Workshop Exp.	5,84,282	2,70,264
UNDP-GEF Project Expenses	63,284	-
Techno Economic Feasibility Study Expenses	-	1,58,284
Other Operational Exoenses	75,850	-
Total	**292,14,865**	**38,70,115**



NATIONAL INSTITUTE OF SOLAR ENERGY

(An Autonomus Institute of Ministry of New & Renewable Energy ,Govt.of India)

Gurgoan-Faridabad Road, Gwalpahari, Gurgaon, Haryana-122003

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2016

SCHEDULE 3- FIXED ASSETS & DEPRECIATION

Amount in ₹

PARTICULARS	GROSS BLOCK					DEPRECIATION				NET BLOCK	
	As at 01.04.2015	Addition before 30.09.2015	Addition After 01.10.2015	Sales/ Adjustment during the year	As at 31.03.2016	As at 01.04.2015	Current Depreciation on L+C	Current Depreciation on D	Total Depreciation (G+H)	WDV as on 31.03.2016 (F-I)	WDV as on 31.03.2015
A	B	C	D	E	F		G	H	I	J	
Desktop Computers	5,33,828	8,33,689	11,30,855	-	24,98,372	1,60,148	7,24,421	3,39,257	12,23,826	12,74,546	3,73,680
Printers and other IT Peripherals	94,100	19,885	5,77,964	-	6,91,949	7,620	15,955	43,347	66,922	6,25,027	86,480
Air Conditioner	9,53,342	-	1,69,339	-	11,22,681	1,43,001	1,21,551	12,700	2,77,253	8,45,428	8,10,341
Misc. Assets Guest House/ Office	28,353	7,52,908	37,46,865	-	45,28,126	2,126	1,16,870	2,81,015	4,00,012	41,28,114	26,227
Scientific & Laboratory Equipments	35,75,686	12,87,908	177,59,479	-	226,23,073	4,62,682	6,60,137	13,31,961	24,54,780	201,68,293	31,13,004
Cycles	40,800	-	-	-	40,800	3,060	5,661	-	8,721	32,079	37,740
Furniture & Fixtures	9,08,154	-	2,13,008	-	11,21,162	45,408	86,275	10,650	1,42,333	9,78,829	8,62,746
Laptops ((Training)	90,195	-	-	-	90,195	27,059	37,882	-	64,940	25,255	63,137
Laptops	90,195	-	3,12,375	-	4,02,570	27,059	37,882	93,713	1,58,653	2,43,917	63,137
Other Assets (Training)	-	4,48,455	6,24,099	-	10,72,554	-	67,268	46,807	1,14,076	9,58,478	-
Office Car	5,49,561	-	-	-	5,49,561	41,217	76,252	-	1,17,469	4,32,092	5,08,344
Softwares	-	3,86,320	9,90,151	-	13,76,471	-	2,31,792	2,97,045	5,28,837	8,47,634	-
Software (Training)	4,22,699	-	-	-	4,22,699	-	2,53,619	-	2,53,619	1,69,080	4,22,699
Total	72,86,913	37,29,165	255,24,135	-	365,40,213	9,19,380	24,35,565	24,56,496	58 11,440	307,28,773	63,67,533



NATIONAL INSTITUTE OF SOLAR ENERGY

(An Autonomus Institute of Ministry of New & Renewable Energy ,Govt.of India)

Gurgoan-Faridabad Road, Gwalpahari, Gurgaon, Haryana-122003

STATEMENT OF GRANTS FOR THE FINANCIAL YEAR 2015-16

Amount in ₹

PARTICULARS	Opening Balance	Refunded during the year	Receipt during the year	Utilization against advances	Utilization against Fixed Assets	Utilization against Revenue	Total Utilization	Closing Balance
Grant -500Wp SPV Power Plant - MNRE	-						-	-
Grant for Creation of Capital Assets	949,33,728	-	659,00,000	539,11,734	292,53,300	-	831,65,034	776,68,694
Grant for Organising International Training Courses	15,00,000	-	-	-	-	-	-	15,00,000
Grant for Training program on Rural livelihood	-	-	30,44,870	-	-	30,44,870	30,44,870	-
Grant for Training program on Energy Access	-	3,612	4,50,000	-	-	4,46,388	4,46,388	-
Grant for NAM & ST Fellowship	-	-	2,70,000	-	-	58,172	58,172	2,11,828
Grant for Training on Small Power Plants	-	-	12,20,000	-	-	-	-	12,20,000
Grant for Project Hydrogen	34,88,854	-	-	-	-	33,05,898	33,05,898	1,82,956
Grant in aid- General	516,44,129	-	675,00,000	73,54,070	-	687,10,877	760,64,947	430,79,183
Grant in aid- Salaries	35,73,800	-	100,00,000	-	-	135,73,800	135,73,800	-
Grant- Skill Development Programme	137,92,742	-	250,00,000	307,90,320	-	120,86,848	428,77,168	-40,84,426
Grant UNDP	-	-	15,00,000	25,000	-	4,02,637	4,27,637	10,72,363
Grant for SERIIUS (Indo US Project)	16,13,539	-	35,16,000	4,09,000	-	31,41,935	35,50,935	15,78,604
Trainning Prog 12 Grant MNRE	36,75,000	36,75,000	-	-	-	-	-	-
Grant for Inaugaration of New NISE Building- MNRE	30,00,000	30,00,000	-	-	-	-	-	-
Grant-INDO-UK STAPP Project - MNRE	13,93,601	-	-	-	-	-	-	13,93,601
Grant for setting up R&D coordination Cell - MNRE	83,49,774	83,49,774	-	-	-	-	-	-
	1869,65,167	**150,28,386**	**1784,00,870**	**924,90,124**	**292,53,300**	**1047,71,425**	**2265,14,849**	**1238,22,803**



NATIONAL INSTITUTE OF SOLAR ENERGY

SCHEDULE 11

SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO ACCOUNTS FORMING INTEGRAL PART OF THE FINANCIAL STATEMENTS FOR THE F.Y. 2015-16

A. SIGNIFICANT ACCOUNTING POLICIES

1. Basis of Accounting

The financial statements have been prepared as prescribed by ICAI in accordance with generally accepted accounting principles. The National institute of Solar Energy (here in after referred to as Institute) adopts cash system of accounting in respect of its incomes as well as expenditure.

The accounting policies adopted and applied in the preparation of financial statements by the Institute are consistent with GFR rules 2005 in general.

2. Fixed Assets and Depreciation

a) Fixed assets are stated at cost less accumulated depreciation.

b) Depreciation has been provided on the basis of rates as prescribed under Income Tax Act 1961.

c) The depreciation has been charged to the grant (Corpus Fund/Capital Fund) and is recognized in the Income & Expenditure account as a contra item as per AS-12 Prescribed by ICAI.

3. Grant in Aid

a) The grants in aid received from Ministry of New & Renewable Energy, Government of India is accounted for on cash basis. The unutilized grants at the end of year have been shown in the financial statements as Grant payable to the Ministry of New & Renewable Energy.

b) The grants utilized for the purchase of fixed assets and have been shown under the head of Capital Assets Fund.

c) Further, grants utilized for advances against Fixed Assets, goods & services have also been shown under the head of Capital Fund.

d) The Institute has changed its policy regarding setting off its revenue expenses with the internally generated resources i.e. Testing and training income in accordance with GFR rules 2005 Chapter 9 Rule 208 (iv). In this financial year, the institute has set off some of its revenue expenditure with the grants received. Surplus from internally generated resources i.e. Income from Testing and Training has been parked to corpus fund.

4. Employee Remuneration & Benefits

All Retirement and other Terminal Benefits such as Gratuity, Leave Encashment and Bonus etc. are not accounted on year to year basis and the same are recognized in the year of occurrence of event.

5. Revenue Recognition

Income and expenditure are accounted for on cash basis, as they are earned or incurred.

6. Provision

A provision is recognized, when an enterprise has a present obligation as a result of past event; it is probable that an outflow of resources will be required to settle the obligation, in respect of which a reliable estimate can be made.

7. Contingent Liabilities and contingent Assets

A disclosure for a contingent liability is made when there is a possible obligation that may, but probably will not, require an outflow of resources. Where there is a possible obligation or a present obligation but the likely hood of outflow of resources is remote, no provision or disclosure is made.

B. NOTES TO ACCOUNTS

1. Expenditure on trainings and seminars to the extent they are reimbursed by the ministry directly, are not disclosed in the financial statements.

2. The depreciation of 48,92,060/- has been charged to the Income & Expenditure account. Since the Institute is fully aided by the Government of India, therefore depreciation is charged to the Grant (Corpus Fund/Capital Fund) and is recognized in the Income & Expenditure account as a contra item.

3. Advances paid against capital assets etc. have been directly set off against Grants. However, in the financial statements the same have been shown separately.

4. Current status of some of the large advance paid in previous financial years is as under:

   - Rs.219.78 lacs were paid to Tata Power Solar Systems for solar power project. The supplier has supplied substantial part of equipment and shall make the project ready for inspection in F.Y. 2016-17. Total advance as on 31/03/2016 was Rs.367.93 lacs.
   - Rs.200.00 lacs were paid to CDAC for upgradation of PV modules, BOS and Lightning system test facilities at Kolkata and Bangalore. The project has been completed in F.Y. 2016-17.
   - Rs.16 crores were paid to NBCC for construction of new building. NBCC has given UCs for Rs.14.24 crores. Payment of Rs.1 crore has been withheld for some defects to be removed. Occupation certificate has been given in the name of MNRE in May 15. Total advance as on 31/03/2016 was Rs.17.90 crores.

VBR & ASSOCIATES CHARTERED ACCOUNTANTS

5. The balances of sundry creditors and debtors are subject to confirmation and consequent reconciliation, if any.

6. Previous year figures have been regrouped and rearranged to make them comparable with those of current year.

As per our Audit Report of even date
For VBR & Associates
Chartered Accountants
(FRN-013174N)

(Binit K Agrawal)
Partner
M. No.088042

Place: Delhi

Dated: December 15, 2016

For NATIONAL INSTITUTE OF SOLAR ENERGY

Dr. Rajesh Kumar
(Dy. Director General)

Er. S. K. Singh
(Director General)