

7: RENEWABLE ENERGY FOR URBAN, INDUSTRIAL AND COMMERCIAL APPLICATIONS





RENEWABLE ENERGY FOR URBAN, INDUSTRIAL AND COMMERCIAL APPLICATIONS

- 7.1 The programmes being implemented during the year include: i) Energy Efficient Solar /Green Building Programme; ii) Energy from Urban, Industrial and Agricultural Wastes/Residues; and iii) Energy from Urban, Industrial and Agricultural Waste/Residues including Biomass Co-generation (non-bagasse) in Industry.

ENERGY EFFICIENT SOLAR/GREEN BUILDINGS PROGRAMME

- 7.2 The Ministry has been implementing a Scheme on "Energy Efficient Solar/Green Buildings" since, February, 2009 which aims to promote the widespread construction of energy efficient solar/green buildings in the country through a combination of financial and promotional incentives mainly for capacity building, awareness, seminar and workshops and other promotional activities etc. Under the "Energy Efficient Solar/Green Buildings" programme following initiatives have been taken up to promote green building construction in the country.
- A GRIHA rating system has been developed in collaboration with The Energy and Resources Institute (TERI) and an independent registered society 'GRIHA Council' is independently providing GRIHA Ratings.
 - 97 building projects of Govt. with 3.05 million sq. m built-up area have been sanctioned for the exemption from the registration cum rating fees for acquiring GRIHA rating. So far, '11' buildings have been awarded GRIHA Ratings.
 - Capacity building programme including trainings, seminar, conferences, and workshops for Evaluators and Trainers on GRIHA Ratings and awareness programmes on Green Buildings/GRIHA Ratings/Green Architecture were organized across the country by various technical institutions.
- 7.3 Under this programme, so far, in the FY 2017-18, Rs. 0.36 Crore has been released towards reimbursement of different capacity building programmes.

DEVELOPMENT OF SOLAR CITIES PROGRAMME

- 7.4 The "Development of Solar Cities" programme aims at minimum 10% reduction in projected demand of conventional energy at the end of five years, which can be achieved through a combination of energy efficiency measures while enhancing supply from renewable energy sources. The Ministry assists Municipal Corporations and Urban Local Bodies in preparation of a master plan for increasing energy efficiency and Renewable Energy supply in the city, setting-up institutional arrangements for the implementation of the Master Plan and awareness generation and capacity building activities.
- 7.5 The Ministry has a target to support 60 cities/towns for Development as "Solar/ Green Cities". Financial support up to of Rs.50 lakh for each city is provided for preparation of the Master Plan along with few DPR (up to Rs.10 lakh), oversight of its implementation (up to Rs.10 lakh), setting up and functioning of Solar City Cell in the city (up to Rs.10 lakh) and organizing promotional activities (up to Rs.20 lakh). So far, under the programme, '60' cities have been approved/sanctioned, of which master plan of 49 cities has been prepared.





- 7.6 Presently five cities namely Bhubaneswar, Chandigarh, Gandhinagar, Mysore and Nagpur are being developed as 'Model Solar Cities' for which the financial support upto Rs.9.50 crore per Model Solar City has been sanctioned.
- 7.7 Also '13' cities namely Agartala, Coimbatore, Rajkot, Shimla, Faridabad, Thane, Raipur, Shirdi, Leh, Aizawl, Puducherry, Vijayawada and Amritsar are being developed as 'Pilot Solar City' for which the financial support upto Rs.2.50 crore per Pilot Solar City has been sanctioned.
- 7.8 So far, cumulative Rs101.60 crore has been sanctioned and Rs 25.95 crore has been released under this programme.

GREEN CAMPUS

- 7.9 A Green Campus aims to reduce fossil fuel based consumption in next five years by 25% through renewable energy applications and energy efficiency measures. The financial support upto Rs.5.0 lakh is provided for developing a green campus in the educational Institutions, office complexes, residential and commercial complexes etc. Upto March, 2017, Ministry has sanctioned financial assistance of Rs.2.60 crore @ Rs.5.00 lakh to '52' institutions (mainly technical/ educational institution) for preparation of Master Plan/ DPR for developing their campuses as green campus and an amount of Rs.1.02 crore is released to them till 31st December, 2017. However, only '13' institutions have prepared Master Plans, so far.

ENERGY FROM URBAN, INDUSTRIAL AND AGRICULTURAL WASTES/RESIDUES

Programme on Energy from Urban, Industrial & Agricultural Wastes/Residues during 12th Plan Period

- 7.10 During the year 2017-18, the Ministry has continued the implementation of the "Programme on Energy from Urban, Industrial and Agricultural Waste/Residues" aimed at generation of biogas, Bio CNG and Power from different wastes, such as municipal solid wastes, vegetable and other market wastes, slaughterhouse waste, agricultural residues and industrial wastes & effluents. About 100 tons/day of municipal solid waste have capacity to generate 1MW of power and 100 tons/day of cow dung can generate about 1600 kgs of Bio CNG per day. In addition to Bio CNG/Biogas, biogas plants generate organic fertilizer as a by-product which is valuable for agricultural fields.

New Initiatives taken by the Government of India

Swachh Urja Se Swachhata

- 7.11 During "Swachhata Hi Sewa" campaign, a Workshop on "Uses of Waste for Energy" was organized on 26th September, 2017 in New Delhi with a message of "Swachh Urja Se Swachhata" to utilize Waste for generation of energy through various proven technologies and established business models. The workshop deliberates upon how to utilize Waste for generation of energy through various proven technologies and established business models and how to scale up programme in close association with all stakeholders including corporate houses.



Ministry of Road Transport and Highways Notification

- 7.12 Ministry of Road Transport and Highways, vide Notification dated 16th June 2015, has amended the Central Motor Vehicles Rules, 1989 and included the provisions for usage of biogas, in the form of bio-CNG, in motor vehicles as mentioned below:-
- Provided that bio-compressed natural gas (bio-CNG) shall be permitted for motor vehicles as an alternate composition of the compressed natural gas (CNG);
 - Provided further that the mass emission standards applicable to compressed natural gas (CNG) vehicles under these rules shall be applicable to respective vehicles when they use bio-compressed natural gas (bio-CNG);
 - Provided also that the bio-compressed natural gas (bio-CNG) composition meets the fuel specification for bio-compressed natural gas (bio-CNG) as per IS 16087 and meets the requirement of Siloxanes max 0.1 ppm (calculated as Si).

Indian Standard on Biogas (Bio-methane)

- 7.13 This standard (IS 16087-2013) prescribes the requirement and the methods of sampling and test for the biogas (Bio-methane) applications in stationary engines, automotive and thermal applications and supply through piped network. Requirements for biogas (Bio-methane) for automotive application and piped network as per standard is as under:-

S. No.	Characteristic	Requirements	Method of Test Ref. to
i)	CH ₄ Percent, Min	90.0	IS 15130 (Part 3)
ii)	Moisture, mg/m ³ Max	16.0	IS 15641 (Part 2)
iii)	H.S. mg/m ³ Max	30.3	ISO 6326-3
iv)	CO ₂ +N ₂ +O ₂ Percent, Max (v/v)	10.0	IS 15130 (Part 3)
iv)	CO ₂ percent, Max (v/v) (when intended for filling in cylinders)	4.0	IS 15130 (Part 3)
v)	O ₂ percent, Max (v/v)	0.5	IS 15130 (Part 3)

Progress during the year 2017-18

- 7.14 During the year 2017-18 following 11 projects were commissioned/supported as on December, 2017.

Commissioned/Supported Projects

- A grid connected power plant of capacity 16MW based on Municipal Solid Waste was setup by M/s. Timarpur Okhla Waste Management Company Ltd. (TOWMCL) at Old NDMC Compost Plant, Okhla, New Delhi.
- 4 Biogas generation projects of installed capacity of 56,500 cubic meter per day for thermal application from industrial effluents/urban waste were set up in Andhra Pradesh and Uttar Pradesh.





- iii) 5 projects of cumulative production of 14,710 kg/day of Bio-CNG, were commissioned in Gujarat, Haryana, Madhya Pradesh and Uttarakhand. A brief on these projects is as under:-
- A plant for production of 6000 kg/day of Bio-CNG from 14,000m³/day of biogas generated from Urban waste was set up by M/s. Greenerth Biogas Pvt Ltd. in Surendranagar District, Gujarat;
 - A plant for production of 600kg/day from 1500 m³/day biogas from poultry litter was set up by M/s Sarovar Agro Farms & Biogas Pvt. Ltd. in Ambala District, Haryana;
 - A plant for production of 1450 kg/day of Bio-CNG from 4000 m³/day from poultry litter was setup by M/s Punchkula Farms Pvt. Ltd in Punchkula District, Haryana;
 - A plant for production of 1200 kg/day of Bio-CNG from 3000 m³/day from cattle dung was setup by M/s Shri Dayoday Urja Evam Jaivik Khaad in Bhopal district, Madhya Pradesh.
 - A plant for production of 5460 kg/day of Bio-CNG from 12000 m³/day from paper industry effluent was setup by M/s Century Pulp & Paper in Nainital District, Uttarakhand.
- iv) A 40 kW off-grid Power plant based on biogas for captive use from dairy industry effluent was setup by M/s Vadilal Industries in District Gandhinagar, Gujarat.
- 7.15 In addition to above, 3 projects of biogas production with cumulative capacity of 48,500 cubic meter per day, 2 projects of cumulative 4000 kg/day Bio CNG generation and one project of 0.5 MW off-grid power generation project in different states were sanctioned and are expected to be commissioned by July 2018.
- 7.16 So far, 24 Grid interactive projects of about 138 MW installed capacity, 70 off-grid power projects of 111.4 MW capacity, 74 biogas generation plants of 5,97,120 cubic meter per day generation capacity and 12 Bio CNG generation plants of 46,628 kg per day generation capacity have been set up in the country.



Shri R.K. Singh Hon'ble Minister of State (IC) for Power and New & Renewable Energy addressing during Workshop on Swachh Urja Se Swachhata



Programme on Energy from Urban, Industrial and Agricultural Wastes/Residues including Biomass Co-generation (non-bagasse) in Industry

- 7.17 The Ministry has been promoting "Programme on Energy from Urban, Industrial and Agricultural Wastes/Residues" including Biomass Co-generation (non-bagasse) in industries for exploiting the potential of biomass power in the form of thermal energy and power for captive use in industry.



1.5 MW biomass co-generation project installed at Sansarpur Terrace, Kangra, Himachal Pradesh

Progress

- 7.18 A cumulative capacity of 662 MW has been commissioned upto 31.12.2017 mainly in the states of Tamil Nadu, Uttar Pradesh, Haryana, Karnataka, Andhra Pradesh, Uttarakhand, Punjab and Rajasthan. State wise details are given in below table.

State-Wise List of commissioned Biomass (Non-Bagasse) Projects:		
S. No.	State	Installed Capacity (in MW)
1	Andhra Pradesh	98.98
2	Chhattisgarh	8
3	Haryana	78.26
4	Himachal Pradesh	7.20
5	Kerala	0.72
6	Karnataka	15.20
7	Madhya Pradesh	12.35
8	Maharashtra	16.40
9	Meghalaya	13.80
10	Odisha	8.22
11	Punjab	128.10
12	Bihar	8.20
13	Rajasthan	2.00
14	Jharkhand	4.30
15	Uttar Pradesh	170.41
16	Uttarakhand	47.50
17	West Bengal	19.92
18	Tamilnadu	28.55
	Total	662.61



8 : RESEARCH, DEVELOPMENT AND DEMONSTRATION (RD&D) IN NEW AND RENEWABLE ENERGY





RESEARCH, DEVELOPMENT AND DEMONSTRATION (RD&D) IN NEW AND RENEWABLE ENERGY

- 8.1 Technology development, validation and standardization are the core requirements for the growth of New & Renewable Energy. In this endeavor, the Ministry New & Renewable Energy (MNRE) supports Research, Development and Demonstration (RD&D) to develop new and renewable energy technologies, processes, materials, components, sub-systems, products & services, standards and resource assessment so as to indigenously manufacture new and renewable energy systems and devices including integration for large scale use of new and renewable energy in the country. The objective of the programme is to make industry competitive and renewable energy generation supply self-sustainable/profitable and thereby contribute to increase share in total energy mix in the country.
- 8.2 RD&D Projects are supported to various R&D/academic institutions, industries, NGO's etc. for technology development and demonstration in the field of solar, wind, solar-wind hybrid, storage, small hydro power, biogas, hydrogen and fuel cells, geothermal, etc. Thrust areas are identified for RD&D. Other activities taken up during the current year include adoption of satellite based tools for wind and solar resource assessment and power forecasting, scheme for awards for innovative ideas and support for entrepreneur development for widespread deployment of New and Renewable Energy for various applications in the country.

Policy and Guidelines

- 8.3 A comprehensive policy framework on Research, Development and Demonstration (RD&D) is in place to support RD&D in new and renewable energy sector, including associating and supporting RD&D earned out by industry for market development. It includes R&D perspective of solar energy as envisioned in the National Solar Mission (NSM) for promotion of solar power in the country. The guidelines have special focus on core-support to R&D institutions to strengthen their expertise in the specific area for technology development and demonstration in association with industry to facilitate commercialization. Ministry provides upto 100% financial support to Government/non-profit research organizations/NGOs and 50% to industry.
- 8.4 The policy framework provides guidelines for project identification, formulation, monitoring, appraisal, approval and financial support. The RD&D projects received from R&D/academic institutions, industries, etc. are evaluated through subject experts. The qualifying projects are appraised by R&D Project Appraisal Committees. The projects recommended by the committees are sanctioned to prospective implementing agencies. The projects are monitored by Monitoring Committees. Projects on completion are reviewed in Project Appraisal Committee Meetings for their achievements.

RD&D Focus

- 8.5 The RD&D efforts are continued with emphasis on cost reduction and efficiency improvement. The thrust areas identified in solar thermal, SPV, biogas, wind, wind-hybrid, storage, small Hydro Power, hydrogen and fuel cells, geothermal, etc. are supported for RD&D Activity. In solar, the focus has been developing high efficiency solar cells, new solar cells, storage and power electronic systems. Projects in solar thermal power generation utilizing solar concentrating technologies have been taken up for technology demonstration and validation for scaling up deployment for power generation and industrial process heat applications including storage.





One such project, 1MWe (3.5MW) Solar Thermal Power Plant with 16 hours thermal storage has been set up for continuous operation at Mount Abu by World Renewal Spiritual Trust (WRST), Mumbai. The project is based on solar concentrating dish technology and storage system. In SPV, a major R&D project "National Centre for Photovoltaic Research and Education (NCPRE), which was taken up in 11th Plan Period at IIT, Bombay was continued in March 2017 for further five years for improving efficiency of crystalline Silicon Solar Cell from 18% to 22% at Lab Scale, apart from R&D in other solar cell materials. In hydrogen and fuel cells, the focus is on technology development and demonstration for hydrogen production and storage for stationary and transport applications. Start-ups for entrepreneur development in renewable energy sector have been supported under an on-going project sanctioned to Centre for Innovation, Incubation and Entrepreneurship (CIIE), IIM, Ahmedabad. In addition to ongoing projects, RD&D projects in the areas of solar thermal, SPV, battery storage and related components, Biogas, hydrogen and fuel cell, small hydro were sanctioned to various R&D/academic institutions, industries for implementation during the current year.

Institutional Mechanism

- 8.6 The Ministry is supporting creation of enabling conditions for institutional mechanism for collaboration for faster development and demonstration of technology for commercialization. The Ministry has taken initiatives strengthening its institutions, namely, National Institute of Solar Energy (NISE), Gurgaon, National Institute of Bio-Energy (NIBE), Kapurthala and National Institute of Wind Energy (NIWE), Chennai with their functions for pursuing RD&D, testing, standardization and certification in solar, bioenergy and wind energy systems, respectively. The objective is to transform them to world class R&D institutions in the respective areas. Centres of Excellences have also been supported at R&D/academic institutions for pursuing research in advanced areas for technology development and training for promotion of R&D in the respective areas.
- 8.7 In addition, the MNRE is also partnering with MHRD for implementation of research projects in NRE under IMPRINT and UAY initiatives. These initiatives envisage supporting projects in consortia including industry for technology development on cost sharing basis by partner ministries/departments/industries. The MNRE has agreed to support one project on thermal storage with 50% cost of the project under IMPRINT.

Review of RD&D Programme

- 8.8 Secretary, MNRE reviewed the progress of RD&D projects funded by MNRE in 12th Plan Period in Jan/Feb 2017 to take stock of achievements and for taking steps to support RD&D in focused manner with emphasis on applications oriented R&D associating industry. The review focused on supporting research and innovation which leads to indigenous development and manufacture of new and renewable energy systems/devices for widespread promotion of new and renewable energy for various applications in the country. It was considered that the RD&D policy and guidelines may be revised orienting the policy framework for supporting projects aiming at applications and scalability.
- 8.9 In pursuance to the Ministry constituted "Panel of Experts" for evaluation of RD&D Programme implemented in 12th Plan Period. The subject-wise "Panel of Experts" appraised projects in respective areas during 14-17th September, 2017 and submitted the evaluation report to MNRE.





The Panel of Experts made recommendation for strengthening RD&D Programme with suggestions for action on support and monitoring of projects.

New Interventions

- 8.10 Keeping in view the fast development in technology due to sustained technology innovation across the globe, the R&D infrastructure created in the country and also “Mission Innovation” that was launched in Paris on 30.11.2015 on the sidelines of the UNFCCC’s COP21, an initiative was taken to prepare a policy which encompasses technology development, demonstration, validation, innovation and start-up with a robust framework and ecosystem aiming at promoting indigenous technology development and manufacture, improving quality and reliability of energy supply. The Ministry has prepared a comprehensive programme for RD&D for Technology Development, Demonstration, Innovation, Validation, Testing and Standardization for RE Sector for the period 2017-18 to 2019-20.

Lab Policy for Testing, Standardization and Certification

- 8.11 The MNRE has initiated the process of making standards mandatory for the entire renewable energy sector. In this regard, the MNRE has brought out a “National Lab Policy on Testing, Standardisation and Certification for Renewable Energy Sector” for quality control. The said policy has brought out clarity about the need of testing and standardization, making the testing and standardization mandatory for entire renewable energy sector with comprehensive plan for strengthening/expanding test labs for the purpose. The policy is an endeavour to ensure reliability and consistency in manufacturing of renewable energy systems/devices. The Lab Policy has been launched on 7th December 2017 and uploaded on MNRE web for implementation.

Notification for Quality Control of SPV Systems/Components

- 8.12 In view of the enhanced target of 100 GW solar power, the MNRE in September 2017 brought out a Quality Control Order for SPV Systems/Components under BIS Act for quality control in SPV power projects. The said Quality Control Order has been notified in government official gazette on 5th September 2017. As per the said order all solar photovoltaics products listed in the same shall follow Indian Standards with effect from expiry of one year from the date of publication in official gazette. Any manufacturer, who manufactures, stores for sale, sells or distributes Goods, shall make an application to the Bureau of Indian Standards for obtaining registration for use of the “Standard Mark” in respect of the Indian Standards given in the same. This is a major step taken by the Ministry for quality assurance in view of major import of solar panels.
- 8.13 The MNRE initiated action for implementation of the Quality Assurance Order. In this regard, the Ministry has decided to reduce the period for enforcement of the said order making it effective with effect from 1/4/2018 so as to ensure quality of the products in the target of solar power projects in the year 2018-19. Secretary, MNRE has taken series of meetings with test labs, industries, project developers, experts, representatives from BIS and Department of Commerce, to review the preparedness of test labs for testing the products listed in the schedules of the order such as SPV Module, Inverters, and Battery Storage. All test labs have been directed to





expedite. NABL accreditation followed by recognition by BIS. New test labs are also planned to be set up in private and government institutions.

Scheme for Awards for Innovative Ideas in New & Renewable Energy

- 8.14 In July 2017, the Ministry launched a scheme for “Award for Innovative ideas in New & Renewable Energy- Abhinav Soch-Nayee Sambhawanayen” to encourage innovation in the sector. The scheme envisages to organize a national level competition at National Institute of Solar Energy Gurgaon for deciding the wards. The awardees will be given cash prizes for their innovation, who will be supported further for scaling up their innovation. The activity has been integrated with TDIP with a provision for support to innovative ideas recognized till commercialization of products.

Space Technology based tools for renewable energy resource assessment

- 8.15 The Ministry has initiated interaction with ISRO for adopting tools and data available with them for resources assessment in solar and wind energy. In this regard, interactive activities between Space Applications Centre (SAC), ISRO Ahmedabad and National Institute of Wind Energy (NIWE) were initiated. As follow up to interaction, activities on validation of satellite based wind and solar data against the ground measured data is being pursued by NIWE. NIWE and SAC are also working for wind and solar power forecasting for Tamil Nadu State.

Start-Ups

- 8.16 The MNRE in February 2011 sanctioned a project “Centre of Excellence to help in scouting and mapping, designing, development and piloting of new and innovative ideas in solar and other renewable energy sector” with total project cost of Rs. 48,00,00,000/- (Rs. Forty Eight Crore), to CIIE, Ahmedabad with a grant-in-aid of Rs. 24,00,00,000/- (Rs. Twenty four crore only) by the Ministry of New and Renewable Energy. The balance cost was to be mobilized by CIIE, IIM Ahmedabad through private investors. Under this project 40 prototyping/piloting and 18 scale-ups have been supported in renewable energy sector. Out of Rs.24 crore sanctioned for the project, a total of Rs.19.4 crore has been released to CIIE for the project till March 2017. CIIE, Ahmedabad has also mobilised Rs.84 Crore from the INFUSE Funds. The project envisages to support a few scale-ups during the current year.

SOLAR R&D

- 8.17 The details of activities being carried under Solar R&D are given below:-

Solar Photovoltaic

- 8.18 For the project entitled “Facilitating the target of 100 GW solar by 2022: An inclusive analysis towards achievement” being implemented by the National Institute for Advanced Studies (NIAS), Bangalore, an introductory white paper was written and two workshops, one at NIAS (Fig.1) and the other in New Delhi, conducted. The two objectives, namely i) Report on



100 GW by 2022 and beyond and ii) Dissemination workshop with stakeholders in New Delhi (planned for end of February 2018), are slated for completion by March 2018.

- 8.19 The Ministry's flagship project in solar photovoltaics being implemented at IIT Bombay and christened National Centre for Photovoltaic Research and Education (NCPRE) Phase II, had several major areas. The progress made in each of these areas is briefly described below.



Fig. 1 Participants from government, industry, academia at Workshop 1 held at NIAS, Bangalore

- (a) **Education and Training** : Seven short-term courses Organized on different aspects of Solar PV for academia and industry. Published book on anti-reflection and light trapping in c-Si solar cells (Fig. 2).
- (b) **Crystalline Si Solar Cells**: Achieved cell efficiency of 18.5 % on 6 inch pseudo square, Al:BSF solar cells. For other cell structures, i.e. PERC and IBC, plans are afoot to use Cu metallization, screen-printed junctions and solution processed passivation layers. An indigenous Ag paste developed jointly with a cell manufacturer that is presently undergoing trials in the manufacturer's production line. Also, developed texturing process for mc-Si wafers sawn using diamond wire saw (DWS).
- (c) **Thin Film Materials and Devices**: Organic solar cells (OSCs) and OLEDs have been developed and studied for their performance. Also, perovskite based OLEDs have been prepared (Fig.3).
- (d) **Energy Storage**: Developed Li-ion cells that can store 2.5 times energy in volume compared to the current technology. Also, 12 V LED glowing with the LiB cells have been developed (Fig. 4). While the batteries developed compare favourably with the commercial ones, these are particularly suitable for grid applications.
- (e) **Power Electronics** :
 - A transformer less, inverter system developed for rooftop PV system working in both on-grid and off-grid modes, with or without battery storage and with over 96 % efficiency (Fig. 5).
 - A universal control for multifunctional operation of inverters in a micro-grid environment has been developed for controlling the line voltage.
 - A high efficiency, permanent magnet, BLDC motor has been developed (Fig. 6) that incorporates MPPT and features a position estimating system for the rotor. It can be used in PV based rural, submersible water pumping applications.
- (f) **Module Reliability**: Conducted all-India survey of PV modules together with NISE team. Won best poster award at the PV Reliability Workshop held at Lakewood, Colorado, USA (Fig.7).





Devised a quick method to identify with thermography hot-spots and other temperature inhomogeneity in PV modules.

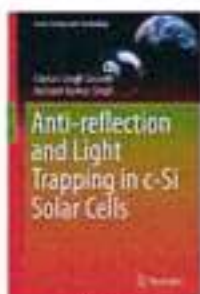


Fig. 2

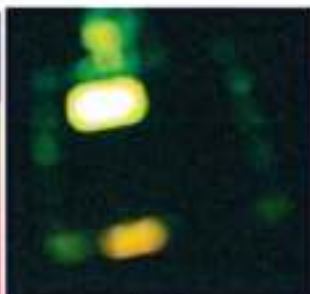


Fig. 3



Fig. 4



Fig. 5



Fig. 6



Fig. 7

- 8.20 In the other MNRE sponsored projects with a large outlay being implemented at Indian Institute of Engineering Science and Technology (IEST), Shibpur, the areas of development included thin film solar cells and BOS components and systems.
- 8.21 The development in thin film solar cells featured development of single junction, a-Si solar cell (9.7% efficient with 17% light induced degradation), microcrystalline solar cells (efficiency of 8.5%), double tandem cells (12 % efficient) and HIT solar cells (16.5 % efficient).
- 8.22 The development in BOS components and systems comprised i) a set of pre-commercial, high efficiency ($> 80\%$ with 20% partial load), robust and cost-effective Central Charging System developed for Solar Lanterns with LED lamps with built-in Overcharge Charge Protection (OCP) and with performance monitoring units like charging current and voltage of each lantern (Fig. 8), ii) a 96V/4kVA grid interactive solar PV inverter (Fig. 9) with an efficiency of 90% , iii) a Grid-tied single-phase, string type 1kW inverter having a transformer-less design and a compact structure (Fig. 10) and with a Total Harmonic Distorsion (THD) of the injected current $< 5\%$, unity power factor and an overall efficiency of 90% at full load condition, and iv) an efficient MPPT based solar PV battery charge controller (Fig. 11) with a power conversion efficiency and tracking efficiency of above 90% and 95% respectively.

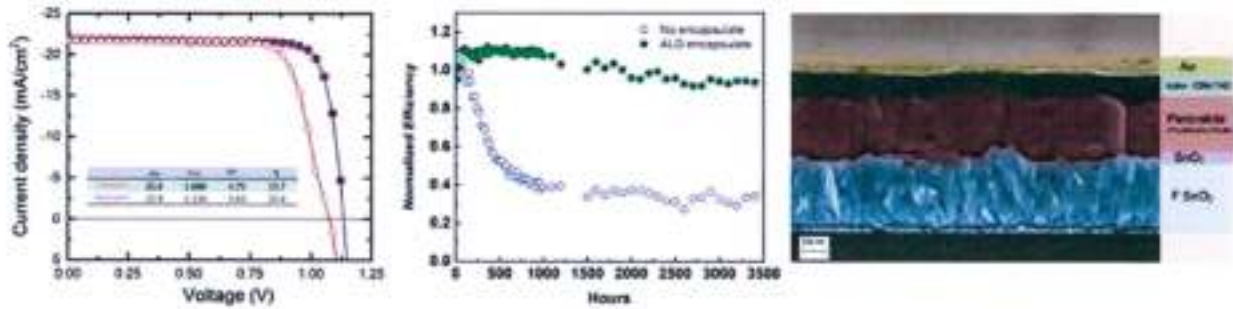




- 8.23 An efficient solar PV turbo charger for super capacitor has been developed. Each super capacitor bank having 2.7 Volts and they are connected in series to have fully charged voltage of 13.5 Volts.



- 8.24 Thin film solar cells based on perovskite has generated a lot of interest in the scientific world due its potential of delivering high efficiency solar cells. In this direction, the MNRE sponsored project being implemented at IIT Bombay has made good progress. The latest report includes claim of 20 % efficient, small area perovskite solar cells (Fig. 12) and a degradation of around 10 % over 3500 hrs (Fig. 13). A cross-sectional SEM picture of a typical perovskite solar cell being developed has been shown in Fig. 14.



- 8.25 The high efficiency and good stability have been developed with a low temperature process (-100°C) and use of atomic layer deposited oxides over the active layer for encapsulation.
- 8.26 MNRE has also sponsored research in the area of growth of silicon material (ingots and wafers) in the country. In a project being implemented at the SSN College of Engineering in Tamil Nadu, a facility has been created with indigenous efforts for growing multi-crystalline silicon ingots through directional solidification (DS) process. The equipment has been fully commissioned (Fig. 15) and is being employed to routinely grow multicrystalline silicon ingots (Fig. 16). The ingots have been diced into bricks and sliced to produce multicrystalline silicon wafers having minority carrier lifetimes of 0.47 micro second (target: 6 micro second).
- 8.27 As against the routine p-type silicon wafers that is used for solar cells, the ones with n-type Si wafers have shown the potential for higher solar cell efficiencies. In an effort to make solar cells using n-type Si wafers, the Meghnad Saha Institute of Technology (MSIT) in Kolkata has set up the facility and started making these solar cells with an improved process. It entails surface texturing, impurity diffusion from BBr₃ source, use of different combination of thin films for the





Fig. 15



Fig. 16

anti-reflection coating and rear passivation etc. Preliminary efforts have resulted in solar cells with 15 % efficiency on 54 sq. cm areas.

- 8.28 In a project aimed at providing drinking water to the masses, NISE has combined with Surya Enertec, a Gurugram-based private company in developing Solar-powered Clean Drinking Water Systems suitable for various locations in the country. The first system (500 LPH, AC pump) installed at the NISE campus (Fig. 17) has been functioning satisfactorily for the past 9 months and has provided 1.5 lakh litres of pure drinking water for the employees of NISE and ISA. The design of future systems based on DC pumps and smaller capacity (100 LPH) is ready and would soon be taken up.



Fig. 17

- 8.29 Apart from this, MNRE sponsored R&D projects also include National Primary Standard facility for cell calibration, being implemented at the National Physical Laboratories (NPL), Delhi, inverter other BOS development projects at Vignan Institute of Technology and Science (VITS), Hyderabad, at ERDA, Ahmedabad, at BITS, Pilani etc.

Solar Thermal

- 8.30 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.
- 8.31 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. The plant is ready after servicing.





- 8.32 A Calibration Laboratory for calibrating the instruments installed in the field under Solar Radiation Resource Assessment Project sanctioned by the Ministry. The laboratory follows all the International standard procedures for calibration of sensors as specified by World Metrological Organisation (WMO) and also by Regional Radiation Center eg; IMD Pune. This project has been implemented by Solar Energy Corporation of India (SECI) in collaboration with NISE, funded by MNRE. Several Pyranometers and Pyreheliometers received from various field stations have been tested.
- 8.33 Setting up of 1 MW el (3.5 MW) solar thermal power plant with 16 hours thermal storage for continuous operation based on parabolic dish solar concentrators designed and fabricated indigenously, at an estimated solar to electricity efficiency of about 12%. The configuration of power plant will include 750 solar dishes having a provision of thermal storage and each having 60 square meter aperture area. The estimated output of the power plant will be i) electrical power of 1 MW el. x 8 hours; ii) electrical power of 800 kW x 16 hours; iii) cogeneration of 1 million liters of hot water and iv) 8 tons of steam for 24 hours. This project has been successfully completed and now under further investigation.
- 8.34 Centre for Excellence in Solar Passive Architecture and Green Building Technologies at CEPT University, Ahmedabad established during 2011 and 2016 under grant from Ministry of New and Renewable Energy, Government of India. Centre was established to enhance the energy efficiency of the building by adopting enhanced construction materials and technologies, create advanced knowledge about thermal comfort and integration of renewable energy in buildings. Centre has met its objectives by providing technical inputs in policy making, providing solutions to achieve energy efficiency to architects and engineers and by developing teaching tools for students. Laboratory infrastructure established under MNRE grant has become one of the best laboratories in south-east Asia.
- 8.35 At MIT, Pune, Desiccant & Ejector concept based system is being developed on Proto basis for application in Air conditioning. It is intended to substitute commercially used Compressor based air conditioning systems by utilizing solar energy harnessed using solar concentrator. The scope includes designing, testing and performance evaluation of both type concepts. Currently, Proto type for Ejector system is getting ready for Performance evaluation while the conceptual design of Desiccant system is in final stages.
- 8.36 Several laboratories/facilities are setup on solar thermal research and education at IIT Jodhpur viz. (a) Solar Resource Assessment, (b) Material Characterization, (c) Solar Thermal, (d) Optics, and (e) Instrumentation and Smart Grid. Both research and teaching activities are actively undertaken in these laboratories leading to development of (a) a tool for resource estimation, (b) high temperature coatings and storage materials, (c) an open volumetric air receiver, (d) a solar air tower simulator facility, (e) the novel concept of solar convective furnace, (f) a radiation calorimeter, (g) a glass-to-metal seal (h) the capability of field design, (i) a PV based 20kW dc micro-grid for integration with other renewable sources.
- 8.37 Indian Institute of Science (IISc), Bangalore, has developed its first prototype of pressurized air solar receiver, as part of the project titled "Development of High Efficiency Receiver for Supercritical CO₂ Integrated with Static Focus Parabolic Dish". This hybrid volumetric and cavity type receiver design consists of open-end dome-end cylindrical cavity surrounded by concentric annular porous medium, as shown in the figure below. Receiver design provides flexibility of testing different materials – steel mesh, ceramic honeycomb and foams. The receiver is to be field tested with a Scheffler dish concentrator having a fixed focus.





Green building testing laboratory

- 8.38. Central Tasar Research & Training Institute (C.T.R & T.I) Ranchi, Jharkhand has taken a lead in "Utilization of solar energy in Trasar post cocoon technology operations" Tasar Silk industry in India is Cottage Industry with an agriculture base and of labour intensive in all its stages i.e. cocoon stifling / drying, cooking reeling, spinning and the post-yarn stage processes like degumming, bleaching, dyeing, printing and mechanical finishing etc. Solar energy can prove to be a cheap, localized source of energy for Tasar silk industry of India. At C.T.R & T.I, Ranchi one 10KWp roof top hybrid solar power plant has been installed and one Hot air dryer for stifling & drying of tasar cocoon is being operated by solar power on trial basis.



Solar receiver fabricated at IISc, Bangalore

Completed projects:-

- 8.39 Development and demonstration of 1 MW capacity solar thermal power R&D project with 16-hour thermal storage at Mount Abu, with co-funding from German Ministry and Indian industry. The project is first of its kind to provide thermal storage of 16 hours and will be based on fully indigenously developed solar dish technology. The project has been commissioned and showed some good initial results. This project provides enormous opportunity in terms of product development and energy storage.
- 8.40 Innovative project "Experimental grid tied solar PV power generation on a waterbody" sanctioned to IGNOU Community College in 2014. Developed lab Scale model, testing equipment, protocol and the standards. A similar floating solar power plant is now being proposed by Kerala Govt. in line with this R&D project's achievements and a new scheme is under process.





Solar Radiation Resource Assessment (SRRA) Stations

- 8.41 In order to strengthen the solar resource assessment and to meet the requirement of availability of Solar Radiation data, In Phase- I program, 51 SRRA stations and in Phase- II, 60 SRRA stations and 4 Advanced Measurement Stations are installed at selected locations spread all over the country. This exercise has been coordinated by National Institute of Wind Energy (NIWE), Chennai an autonomous institution of the Ministry. A central server facility for data collection from all these stations has been set up at NIWE. The data so collected will be useful in developing a solar atlas for the country. In addition, all the solar power projects selected under the Mission have also set up radiation monitoring equipment at their project sites. **NIWE has launched a Solar Atlas of India for firming of solar potential of the Country.**

SMALL HYDRO POWER

- 8.42 Two R&D Projects supported by Ministry are ongoing in IIT Roorkee in the area of Hydro power focused on "Development of Efficient Cross Flow Turbine for Hilly Region" and Development of laboratory for sediment monitoring and impact analysis studies in Hydro Power plant. The R&D project for establishing a Small Hydro Hydraulic Turbine Laboratory at AHEC, IIT Roorkee was supported by this Ministry. The project aims at setting up of Small Hydro Turbine testing Laboratory, Model Testing of hydraulic turbines, human Resource Development, Design and R&D in the area of hydro turbines including hydro-mechanical equipment, control and instrumentation of small hydroelectric power plants.

BIOGAS RESEARCH, DESIGN AND DEVELOPMENT

- 8.43 Biogas Technology Development Division promotes research and innovation and persuaded projects for Research, Design, Development and Demonstration in Biogas Technology area. Ministry funded three R&D projects are ongoing for "Development & Performance Evaluation of a 3 kW biogas based power generation system utilizing Lignocellular Biomass", "Development of Hybrid-High rate Bio-methanation Reactor using locally available media for treating waste water and solid waste"; and "Development of Suitable Pre-treatment System for Paddy Straw Disintegration for Biogas Generation Leading Towards Commercialization of Technology "at IIT-Guwahati, Tamil Nadu Agricultural University, Coimbatore, and Centre for Rural Development and Technology, IIT Delhi, respectively. The R&D project entitled "Design and Development of Mobile Unit for Biogas Enrichment funded to IIT, Delhi was completed in 2017-18".



Experimental set-up for Bio-methanation reactor at TN&U Laboratory





Laboratory scale hydrothermal reactor at IIT, Delhi

A view of hydrothermally pretreated paddy straw at IIT, Delhi

Biogas production studies in 100 L continuous feed digester at IIT, Delhi

HYDROGEN ENERGY AND FUEL CELLS

- 8.44 The Ministry has been supporting a broad based Research, Development and Demonstration (RD&D) Programme on different aspects of hydrogen energy technologies that includes production of hydrogen, its storage and utilisation for stationary, motive and portable power generation applications using internal combustion engine and fuel cells and also for other applications. As on 31.12.2017, a total of 22 RD&D projects on different aspects of hydrogen energy and fuel cells are under implementation.
- 8.45 On-going projects include development of electrolyser based hydrogen dispensing station at Indian Oil Corporation, Faridabad; Hydrogen fuelled vehicles developed by IIT Delhi and Mahindra & Mahindra (3-wheelers, mini-bus); Hydrogen Production facilities through biological routes at IIT Kharagpur and through biomass gasification at IISc Bangalore; and development of Hydrogen Storage materials (solid hydrides) at Banaras Hindu University.
- 8.46 RD&D Projects on "Development and Demonstration of Diesel Hydrogen Dual Fuel SUV" by Mahindra & Mahindra, "Mission Mode Project on Hydrogen Storage in Carbon Materials" by IIT Madras, "Development and Demonstration of Hydrogen Fuelled Multi Cylinder SI Engine Generator Set for Stationary Power Generation" by IIT Delhi, "Mission Mode Project on Hydrogen Production through Biological Routes" by IIT Kharagpur and ICT Hyderabad, and "Demonstration and performance evaluation of various technologies of hydrogen energy" by National Institute of Solar Energy, completed during this year.
- 8.47 In August 2017, Ministry constituted a Panel of Experts for evaluation of RD&D project proposals and re-constituted the four Project Monitoring Committees for independent monitoring and evaluation of RD&D projects being implemented with Ministry's support in the Hydrogen Energy and Fuel Cells domain.



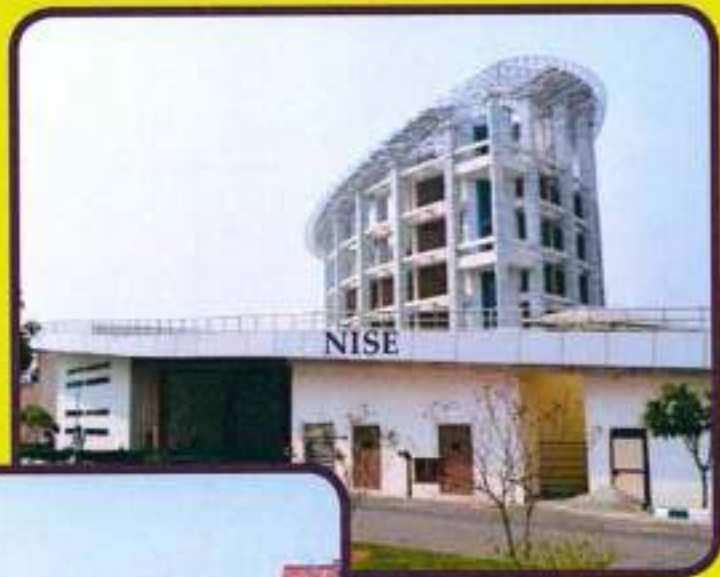


Fuel Cell bus developed by Tata Motors demonstrated at the event in IIT Bombay

- 8.48 National Consortium Advancing Hydrogen and Fuel Cell Technology was organized by the Ministry in collaboration with Tata Group on 15 December 2017 at IIT Bombay. The event saw participation from subject area experts from industry, academia, and consulting groups. Hydrogen and Fuel Cells Technologies and prototypes developed in the country, including with MNRE support, were exhibited during the event.



9 :
SPECIALIZED
INSTITUTIONS



SPECIALIZED INSTITUTIONS

NATIONAL INSTITUTE OF SOLAR ENERGY (NISE)

- 9.1 National Institute of Solar Energy (NISE), an autonomous institution of Ministry of New and Renewable (MNRE), is the apex National R&D institution in the field of Solar Energy. The Government of India converted the 25 year old Solar Energy Centre (SEC) under MNRE to an autonomous institution in September 2013 to assist the Ministry in implementing the National Solar Mission and to coordinate research, technology and other related work.
- 9.2 NISE has assumed all technical activities of SEC and has also re-organized itself to undertake roles and responsibilities assigned to it by the Ministry. The institute is involved in demonstration, standardization, interactive research, training and testing of solar technologies and systems, serving as an effective interface between the Government and institutions, industry & user organizations for development, promotion and widespread utilization of solar energy in the country.
- 9.3 NISE is maintaining an NABL accredited Solar Photovoltaic module testing laboratory, lighting system test laboratory, battery testing facility and a water pumping system test rig and outdoor test facilities. The Institute has fully developed testing facility for small and large size solar thermal systems and Solar Resource Assessment.
- 9.4 A new building named "Surya Bhavan" and 30 room international guest house with solar passive concept is fully functional. It is proposed to meet the entire electricity requirement of the campus through solar energy and make it a "net zero electricity consuming campus".

Major Facilities at NISE and Activities Undertaken during 2017-18

- 9.5 The NISE has undertaken the following activities during 2017-18:

SOLAR RADIATION RESOURCE ASSESSMENT

- 9.6 Solar Radiation Calibration Laboratory (SRCL) at NISE has commenced calibration program of Phase-II Solar Radiation Resource Assessment (SRRA) stations. Phase -II of SRRA has all the Hukseflux make sensors in operation for which all necessary equipment were procured by NISE for performing their calibration at its facility. As an extension of calibration services to any organization in the country, commercial mode was also initiated. During the year SRCL has calibrated a total of 18 sensors from 6 SRRA Phase-II stations and 8 sensors from various private companies under commercial calibration mode. The calibrated sensors stations details are given in following table:

S. No.	Details of the stations		No. of sensors calibrated at SRCL		Total
			Pyranometer	Pyrheliometer	
1	Phase-II SRRA stations	Chandigarh	2	1	3
2		Kapurthala	2	1	3
3		Murthal	2	1	3
4		Solan	2	1	3
5		Ranchi	2	1	3
6		Jamshedpur	2	1	3
7	Private Organization		8	0	8
Total			20	6	26





SOLAR PHOTOVOLTAIC SYSTEMS AND DEVICES DIVISION RESEARCH AND DEVELOPMENT

Study on Performance and Reliability of PV Modules installed in the country

- 9.7 The joint project of NISE and NCPRE, IIT Bombay initiated to study the field performance of SPV modules installed over period of time ranging from 20 years to recent installations in different climatic conditions of India was continued during 2017-18. Performance data collected from different locations is being analyzed to understand the reliability and process of degradation of PV modules under Indian field conditions. The report is under preparation. The study of performance of PV power plants will be initiated in March 2018 under this joint activity.

Net metering of NISE

- 9.8 NISE has more than 800 kWp SPV power plant capacity installed in the campus and new power plants are going to be added. NISE is moving towards the NET Positive Energy campus by next year. NISE is feeding power to the grid through net-metering from PV power plant during the day time.

Secondary Reference Cell Calibration for Large Area Solar Cells

- 9.9 NISE along with IIT Bombay, Mumbai; National Physical Laboratory (NPL), New Delhi; and Fraunhofer-Institut für Solare Energiesysteme (ISE) Germany has been working to develop a secondary reference cell calibration facility in the country for commercial solar cells of 6 inch x 6 inch size. Under this project, Round Robin testing of large area (5 inch and 6 inch square) mono and multi-crystalline silicon solar cells was taken up at NISE, IIT Bombay and NPL, New Delhi, in India and Fraunhofer Institute for Solar Energy (ISE), in Germany. Comparison of I-V measurements made at these four centres on several large area solar cells, with the measurements made at ISE taken as the benchmark revealed the extent of deviation in measurements made at different laboratories. The study also brought out the specific improvements that have to be made on the respective setups.

Performance Comparison of Thin Film Module in India and USA, A Joint Project between NISE and NREL, USA

- 9.10 NISE 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 6 of these modules to NREL. The thin-film modules were deployed in outdoors in December 2013. First joint technical report with NREL is already published. The result has been presented in the conference on Reliability of PV module organized by NREL. The long term measurement of performance of the modules is still going on.

SERIIUS Project

- 9.11 Under the Solar Energy Research Institute of India and the United States (SERIIUS) project NISE is carrying out the reliability and performance studies of various technology modules under different climatic zones in India. The main deliverables from NISE under the project are:





- i. Identification of climatic zones and environment conditions.
 - ii. Modelling of the performance studies of various technology modules under different climatic zones.
 - iii. Preparation of general specifications of PV modules and components.
 - iv. Development of models using time dependent performance reliability indicators.
 - v. Dust effect and mitigation in different climatic zones of India.
- 9.12 NISE is working on the quantification of reliability index of PV module based on the field data measured for different climatic zones. Designing of testing conditions for Indian climate for PID of PV modules is going on. Currently the project is extended up to March 2018.

TESTING AND PERFORMANCE EVALUATION

Solar Cell Characterization Laboratory

- 9.13 The Solar cell characterization laboratory at NISE that features a Class AAA solar simulator has recently been upgraded with incorporation of an indigenously designed and fabricated four-probe contacting system and an accurate temperature-controlled water bath. Currently, the system has been designed for contacting solar cells having up to 4 bus bars. However, plans are afoot to extend it within this financial year to solar cells with five bus bars. The system is being used for validation of cell efficiency claims made by R & D Institutions, Universities and industries implementing MNRE sponsored projects on development of high efficiency solar cells, as well as other cell manufacturers. The versatile system has the ability of making I-V measurements on small as well as large area solar cells under STC as also under different conditions of temperature and insolation. Solar cells from IEST, Shibpur, IIT, Bombay and BEL, Bangalore have recently been measured using the I-V tester at NISE. The facility would soon be further equipped with the addition of a spectro-radiometer and a spectral response measurement system for solar cells.

Outdoor PV Module Testing Facility

- 9.14 The Outdoor PV Module Testing Facility has been set up for performance evaluation of different technology modules on real time basis in the field under Indian climatic conditions based on IEC 61853 standard. A new multi-channel PV PM system has been commissioned for evaluation of a number of modules and arrays simultaneously under the same environmental conditions. A new set up of Electroluminescence camera has been designed for solar PV module with the help of NCPRE, IITB. Outdoor PID testing of PV module is being added to the lab. This lab has published more than 25 papers this year.

Mobile Testing lab for inspection of PV power plant

- 9.15 A Mobile test facility has been created at NISE for testing/evaluation of PV power plant performance in actual working/field conditions in India. A bus has been designed for this activity. The procurement of instruments for the Mobile test lab is going on.





POWER ELECTRONICS LAB

Advanced SPV Systems and Lighting Laboratory

- 9.16 This laboratory, with well-equipped testing facilities, is engaged in testing of performance and reliability of solar based lighting systems as well as validation of field performance. The laboratory is involved in R&D in the field of application of Solar Photovoltaic systems & Illumination Engineering. This is the first Solar Lighting laboratory deployed by MNRE to promote Solar PV Lighting program in rural India. The major Solar PV lighting systems promoted by MNRE include portable Solar Lanterns, Solar Home Lighting and Solar Street lighting systems, etc. It is necessary that products and devices have the desired quality, efficiency, reliability, ruggedness and ease of operation.
- 9.17 NISE offers advice to manufacturers for improving the quality and helps in preparing the performance guideline through its testing activity. MNRE has developed its own technical specifications for Solar Lanterns, Solar Home Lighting Systems, Solar Street Lighting Systems etc. Recently, MNRE revised the technical specification (i.e. Off-grid Solar Applications Scheme 2016-2017), and a few changes have been done in the system design in solar lantern, home lighting system, and street lighting systems with motion sensor. A Solar Power Pack for DC & AC models and home lighting systems with batten type luminary was introduced. W-LED lamps which include the solar Inverter of 24V/300VA, Pure Sine wave, PV integrated Micro solar dome and LED based solar home lighting system with batten type luminary are also introduced in the new technical specifications of MNRE.
- 9.18 The Laboratory has tested lighting systems and generated revenue of more than Rs. 60 lakh in the financial year of 2016-17 which is twice the revenue generated in the financial year 2015-16.



Virtual Visit to the Advanced SPV System & Lighting Laboratory





Solar Water Pump Testing Facility

- 9.19 NISE has a testing facility for certification of SPV water pump systems as per MNRE specifications and user requirements, for performance evaluation and analysis, optimization of different types of pumps (AC & DC and surface & submersible pumps), of capacities ranging from 0.5 HP to 10 HP for different heads from 10 m to 100 m.
- 9.20 During the year, NISE tested 56 different types of SPV water pumping systems. A fully automatic in-door and outdoor SPV water pump testing facility was commissioned in July 2016 at NISE which is capable of testing eight SPV water pump samples at a time. It takes 7 days for outdoor testing and 2 days for indoor testing with the use of array simulator for different day profiles taking temperature and irradiance correction into account to complete the testing of pumping system. The other testing activities undertaken by NISE are:
- 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 in different climatic zones of India.
 - Collaboration with renowned industries for technical advancement and knowledge sharing.
 - Development of a Standard of SPV Water Pump testing.

500 kW Photovoltaic Power Plant

- 9.21 The 500 kW SPV Power Plant with five different technologies, i.e. Copper Indium Gallium Selenide (CIGS), Cadmium Telluride (CdTe), Hetero-junction Intrinsic Thin film (HIT), IBC (Sunpower), and Crystalline Silicon has been commissioned in the campus of NISE. Out of 500 kW, 200 kW is connected with battery storage and hybrid inverter. The balance 300 kW is connected to the grid. The power plant would be used for research and field reliability testing of different technologies in the same climatic condition and for establishing a mini-grid. Grid stability would also be maintained or analyzed.

Solar Design Simulation Lab

- 9.22 Solar Design Simulation Lab, a new initiative of NISE, has been set up for the development of project proposals, consultancy, training and other research and development purposes during this year. This Lab is a full-fledged functioning lab, with audio visual facility for the demonstration. There are different software available in this laboratory which can be used for the design of PV power plant.
- 9.23 The Solar Design Simulation Lab has been providing consultancy on different SPV projects and training the people of different backgrounds from industries, educational institutions, etc. This lab has trained more than 220 senior engineers and managers from SJVN, BHEL, NTPC, REC, THDC, PCRA; teaching faculty of different universities, new solar entrepreneurs, businessmen and international trainees through ITEC and sixteen system design programs at NISE during the year.





SOLAR THERMAL TECHNOLOGIES

- 9.24 NISE has undertaken various research projects on solar thermal energy for cooking, heating, cooling, power generation, process heat applications, desalination, thermal storage, bulk milk chilling system using thermal storage, cold storage facility with thermal storage and in-house research and development etc. The following facilities have been set up NISE campus:

Solar Thermal Research and Development Projects

- 9.25 Research and development activities were continued for performance evaluation and system optimization of the 100 kW High Efficiency Solar Thermal Triple Effect Absorption System, 15 kW Absorption Prototype System with Air Cooling, 5 kW Adsorption Prototype System, 3x3 kWp Solar Stirling Engine, Distillation system, PV based bulk milk chilling system with thermal storage, PV based cold storage with thermal storage for continuous operation, Solar Air-Dryer and PV based heat storage for cooking.

1 MWe Solar Thermal Power Plant

- 9.26 A 1 MW Solar Thermal Power Plant based on parabolic trough collector and Linear Fresnel Reflector technologies was 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. The unique feature of this plant is the integration of two different solar fields (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. The plant was non-functional since August 2015. Operation and maintenance of the plant was undertaken by NISE during the year. The plant is expected to become fully operational by March 2018.

Solar Thermal Test facilities for CST

- 9.27 NISE has created a facility for characterization and testing of all types of concentrator technologies. This includes Hot water/ Steam based Test Set Ups, Thermic fluid based Test Set Up, FPC and ETC, Cooker Test Facility as per BIS standard and MNRE Specifications. 3 nos. of CST technologies, 1 no. of Flat Plate Collector and 1 no. of Evacuated Tubular Collector. All of these have been tested and certified through the year.

Mobile Test Set Up

- 9.28 Mobile test facility has also been procured for testing/evaluation of performance of different thermal technologies in actual working/field conditions. The scientific teams have visited and studied the performance and degradation in the performance of different concentrated solar thermal technologies being used for process heat applications across India.





CO-ORDINATION OF NATIONAL RESEARCH ACTIVITIES IN SOLAR ENERGY

- 9.29 NISE has been entrusted with the coordination work of National Research Activities in Solar Energy by MNRE, including scrutinizing the R&D project 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. It has also been responsible for monitoring the on-going R&D projects through expert visits, organizing reviews, suggesting mid-course corrections, and monitoring and verifying claims as an independent, un-biased agency. Recently, a new trend has been set at NISE by conducting review of the on-going R&D projects in PV and ST through an interactive meeting at NISE of the internal and external experts as well as all the PIs. These meetings would be held every six months to have close monitoring of the projects.

Solar Photovoltaic R & D Projects

- 9.30 Since April 2017, around 35 new project proposals have been received in PV for evaluation and further processing. The proposals in PV are divided into two broad groups namely a) PV cells & materials and b) PV systems and applications with more number of proposals belonging to the systems and applications category. These are internally screened before sending to external experts for further evaluation. Results of evaluation for around 17 project proposals in PV are being prepared for submission to the Ministry. These would be further evaluated at the meetings of RDPAC and RDSPAC. The results of evaluation of the remaining 18 proposals would be sent to the Ministry before the end of the financial year 2017-18.
- 9.31 NISE has also been regularly carrying out monitoring of the on-going MNRE sponsored projects in solar photovoltaics by conducting biannual meetings of the Project Review Committee at NISE wherein the PIs of the on-going R&D projects make brief presentations and describe the progress made in the respective project. The Minutes of Meeting entailing specific recommendations in respect of each project is then sent to the Ministry for further action.

Solar Thermal R&D Projects

- 9.32 Since April 2017, around 30 project proposals have been received in solar thermal energy for evaluation and further processing. These projects were mainly on small scale power generation, solar refrigeration and air-conditioning, solar cookers, solar distillation and solar industrial process heating. All these projects have been evaluated by experts and RDPAC and RDSPAC meetings were organized. The expert panel has also been updated and a meeting of experts for evaluation and midterm correction was organized for all the ongoing projects.
- 9.33 As a part of NISE's outreach programme, under the institute serial publication series (multi-volume), one new volume (Volume-4) of the book entitled "Advances in Solar Energy Science and Engineering" dealing with Policies for Renewable Energy and Energy efficiency was published during the year with an objective to provide quality literature in the field of Solar Energy to all the stake holders.

TRAINING AND SKILL DEVELOPMENT

Skill Development Division

- 9.34 NISE has been assigned with the responsibility to execute the various skill development programmes throughout the country in the field of solar energy technology. At present various





programmes are being conducted at NISE and its partner institutes across India. The focus of the programme is on technology development, system design, installation, commissioning, operation & maintenance and repair, etc. The capacity building activities under the skill development programme of NISE are as follows:

Suryamitra Skill Development Program

- 9.35 NISE is implementing “Suryamitra” training program to train the ITI/diploma holders as field technicians to provide a skilled work force for installation, commissioning, operation and maintenance in the field of solar technology to execute National Solar Mission (NSM) programme across the country. NISE has identified a network of institutions through State Nodal Agencies (SNAs) to conduct training programmes. It provides funds to these agencies and also monitors the skill development programmes implemented by them. Separately, NISE is also organizing Suryamitra programme in its own campus. Under Suryamitra programme a total of 72 programs with 2208 Suryamitras, have been organised in FY 2017-18 till 31.12.2017. Since inception, a cumulative number of 542 programmes have been conducted by NISE and other implementing agencies approved by it and a total of 16,161 Suryamitras have been imparted trainings under this programme up to 31.12.2017, including 5,148 during 2017-18.

NISE Skill Development Programs

- 9.36 NISE has been conducting Solar and Renewable Energy trainings for the past two decades for national and international participants. NISE regularly invites people from solar and renewable energy industry and interacts with them to identify the skill gaps in the new recruits of the renewable energy industry. A dedicated training programme on Renewable Energy Technologies for senior defence officers is also being conducted on a yearly basis. Besides, NISE is also organizing a number of other training programmes for start-ups, solar PV roof top projects, SPV pumps, solar thermal technologies and hydrogen energy and fuel cells. NISE has also planned to start a long term programme for solar professionals for six months duration from February 2018. A total number of 17 training programs on various aspects of Solar Energy by imparting training to over 900 participants have been organized in 2017-18 till 31.12.2017.

International Training Programmes

- 9.37 Ministry of External Affairs, Govt. of India has identified NISE as a premier institute to conduct Indian Technical and Economic Cooperation Programme (ITEC) every year for international participants along with other international programmes like Indo African Forum Summit (IAFS) and Programme for SAARC countries. NISE has conducted 3 International Programmes in FY 2017-18 till 31.12.2017 and 3 more are scheduled by 31st March 2018. These programmes are for a duration of three-weeks, focused on latest Solar and Renewable Energy Technologies. Apart from ITEC, IAFS and SAARC programme, NISE has also conducted 2 programs for International Solar Alliance (ISA) member countries in FY 2017-18 till 31.12.2017. A total of 101 participants from 66 countries have participated in these International Training Programmes.





COORDINATION ACTIVITIES

- 9.38 NISE has been maintaining a good coordination with various national and international organisations to augment its strength and use their capabilities and expertise. Three International MoUs developed and finalized with National Solar Energy Institute (CEA-INES), France, National Electronics and Computer Technology Centre (NESTEC), Thailand, and United Nations International Development Organization (UNIDO) have been submitted to MNRE for approval.
- 9.39 MoUs have been signed with the following national organizations:
1. National Power Training Institute (NPTI)
 2. The Energy and Resources Institute (TERI)
 3. AFC India Limited
 4. Solar Energy Corporation of India (SECI)
 5. Central Board of Irrigation and Power (CBIP)

CONSULTANCY SERVICES

- 9.40 Consultancy is one of the key competencies of the institute. With an excellent pool of scientific manpower and management experts, NISE is extending various consultancy services like site survey, preparation of Detailed Project Report, Solar System Design and vetting of tender documents and specifications, Project management & EPC advisory, Solar Feasibility Report / DPR on solar photovoltaic & solar thermal technologies, solar power plant performance evaluation & monitoring in the field, and testing & performance of the solar systems with the help of Mobile Lab facilities etc. Institute has active collaborations and MoUs with prominent national & international organizations in the area of solar energy technologies for consultancy work. During 2017-18 NISE has extended following consultancy services:-

Sl. No.	Projects undertaken/Evaluated during the last few years
1.	Preparation of feasibility Report for 750 kWp Solar Power Plant at Sheetala Mata Mandir Gurgaon.
2.	Preparation of feasibility Report for 3.0 MW Solar Power Plant at Indian Naval Academy Ezhimala, Kannur, Kerala
3.	Preparation of feasibility Report for 200kWp Solar Power Plant at Huaaini village Haryana.
4.	Vetting of DPR for "210 kWp grid connected solar power plant at Kesrisinghpur under garrison engineer Sri Ganganagar Military station" submitted by Nitasha Constructions Ltd.
5.	Vetting of DPR for "1.5 MWp solar power plant, at Air force station Nal, Bikaner Rajasthan, submitted by Nirman Encon Projects Pvt. Ltd.
6.	Site survey of Rooftop Solar Power plant & field verification of Street Lighting System of Government Organisations.





HYDROGEN ENERGY & FUEL CELLS FACILITY

- 9.41 A solar hydrogen production cum dispensing facility was installed and commissioned in the campus of the National Institute of Solar Energy (NISE) in December, 2014. The facility became operational in late 2015 after adequate hydrogen got accumulated in high pressure storage tubes of the facility. Thereafter, NISE has been operating and maintaining the facility for regular production and dispensing of hydrogen. This is the first of its kind facility in the country to utilize solar energy for the production, storage and dispensing of hydrogen.



Hydrogen facility at NISE



H₂-Diesel Dual Fuel Vehicles developed by M&M

- 9.42 NISE continued to implement an R&D Project entitled "Demonstration and Performance Evaluation of Various Hydrogen Technologies" sanctioned by the Ministry of New and Renewable Energy in December, 2014 with a broad objective of demonstration and performance evaluation of various technologies of hydrogen energy at NISE. During the year, the facility continued to be used for providing hydrogen for trial runs of two hydrogen-diesel dual-fuel vehicles, developed by M/s Mahindra & Mahindra under an R&D project assigned to them. This facility has been set up at NISE in accordance with clearance of Petroleum and Explosives Safety Organisation (PESO). Field trials of hydrogen-diesel dual fuel vehicles being carried out by Mahindra & Mahindra in association with NISE have indicated that the vehicles on one side showed improved performance in dual fuel mode and reduced emissions on the other compared to diesel only mode of operation. Two vehicles were run using hydrogen fuel in association with Mahindra and Mahindra. These vehicles have completed over 29800 kilometers on hydrogen fuel.
- 9.43 Efforts for setting up of a Fuel Cell Testing Laboratory were initiated and the infrastructure required for operation of fuel cell system was completed during the year. 1x2 kW and 2x1 kW Polymer Electrolyte Membrane Fuel Cell (PEMFC) systems that were procured earlier were operated under demonstration mode and these systems were operated for a cumulative total of 50 hours using commercial bottled hydrogen. Hydrogen leak detectors with alarms are installed for safety purposes. The up-gradation of the laboratory is likely to be taken up in the future.





9.44 An MoU has been signed between NISE and M/s Tiger Power, Belgium to have a collaborative project for the validation of a hybrid system comprising SPV system – Batteries – Electrolyser – Hydrogen Storage – Fuel Cell and its techno-commercial viability in Indian climatological conditions. The first segment of the project from M/s Tiger Power, Belgium has been installed in the campus of NISE. This segment consists of a 4.77 kWp PV panel along with storage batteries of 14.4kWh (24 number of batteries of 2V and 300Ah capacity of each) and inverter installed on the top of a shipping container. This facility has remote monitoring, which enables performance evaluation of the PV system in Indian conditions.



Fuel cell testing laboratory setup (inside the lab)

9.45 The 2nd National Workshop on Hydrogen Energy and Fuel Cells was organized successfully in NISE during 22-23 November 2017. This workshop provided a platform to researchers from academic institutions, research laboratories, industries and individual professionals to interact and exchange views on hydrogen and fuel cell technologies. Based on the deliberations during



A Hybrid System installed in NISE by M/s Tiger Power, Belgium under a collaborative project





the workshop, a report and recommendations have been prepared by the NISE and sent to MNRE for review.



Participants of 2nd National Workshop on Hydrogen Energy and Fuel Cells

NATIONAL INSTITUTE OF WIND ENERGY (NIWE)

- 9.46 The main activities of National Institute of Wind Energy (NIWE) include research and development to achieve and maintain reliable and cost-effective technology in Wind Power systems; Wind and Solar Radiation Resource Assessment; preparation of standards for wind turbine testing and certification of wind power system; information dissemination; human resource development; offer various consultancy services to customers; and to serve as a technical focal point for wind power development in India and support the growing wind power sector in the country.

WIND RESOURCE ASSESSMENT & OFFSHORE UNIT

- 9.47 The objective of the Nation-wide WRA program is to quantify the wind resource availability in the country with a view to generate power from wind. The program envisaged setting up of dedicated wind monitoring stations at carefully chosen sites across the country under various WRA programs are of 50m 80m, 100m and 120m height. The data collected under the program is being used widely to establish wind farms in the country and is noted that all the wind farms established in the country till now is based on the reference data collected under this National Program of wind resource assessment. As on date, 832 dedicated wind monitoring stations have been established with the help of State Nodal Agencies. 34 Wind monitoring stations are under operation and 21 new wind monitoring stations commissioned (7 in Chhattisgarh, 7 in Assam, 6 in Meghalaya & 1 in Gujarat).

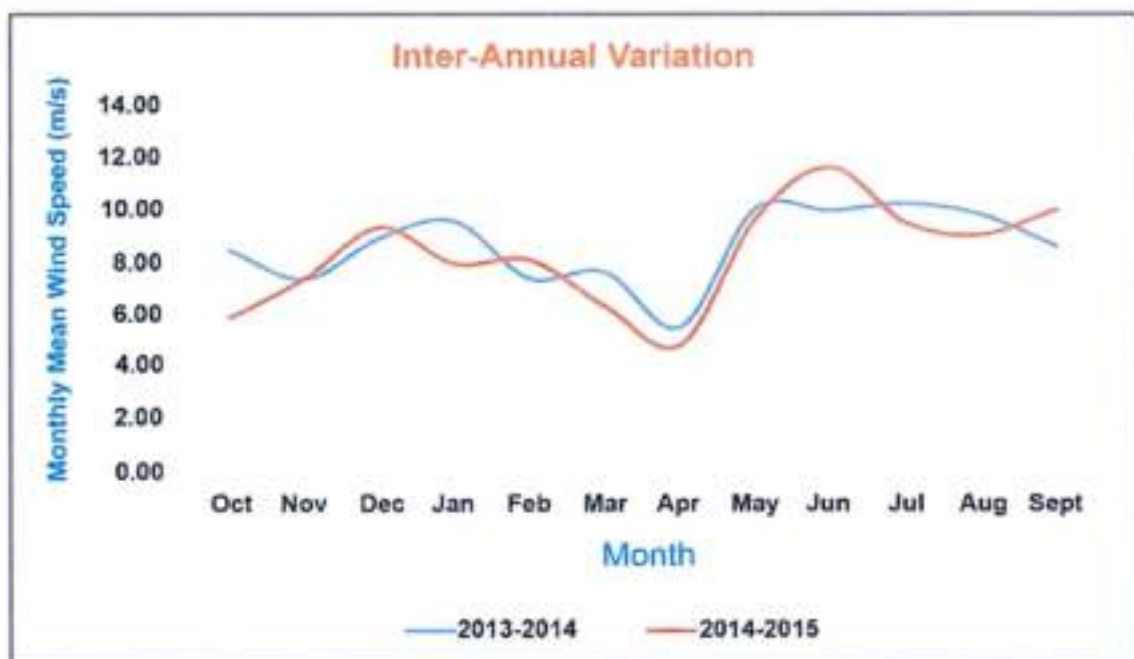




- 9.48 58 sites have been registered for wind measurement by private sector from various states in India. The wind data from over 46 private Wind Monitoring stations have been analyzed. Forty four consultancy projects focused in various wind farm developmental needs were undertaken for a variety of clients from public/government/private sector during this period.

Offshore Wind Resource Assessment at Dhanuskodi

- 9.49 NIWE has carried out offshore wind energy potential pre-feasibility in South India in collaboration with RISO, DTU, the area from 77° to 80° Eastern longitude and 7° to 10° Northern latitude using Advanced Synthetic Aperture Radar (ASAR) during the years 2002 to 2011. The ocean wind speed maps are retrieved and processed at Risø DTU. The results show wind energy density from 200 W/m² to 500 W/m² at 10 m height above sea level. In order to validate the satellite study, a 100m lattice wind mast was installed and commissioned at the tip of Dhanushkodi, Rameswaram. Data from this wind monitoring station at 10m, 50m, 80m, 100m and 102m is being collected since October 2013. The results obtained from the measurement campaign are promising and encouraging. The report on Offshore Wind Resource Assessment at Dhanushkodi is published in NIWE website:-(http://niwe.res.in/assets/Docu/Offshore_Wind_Resource_Report_Dhanuskodi.pdf).



Inter-Annual Variation Graph for Dhanuskodi Measurement at 102m

Research Met Mast

- 9.50 To conduct a R&D study on the influence of mountain pass on wind flow and its impact on the power generation, a study would be carried out by installing two 50m wind monitoring stations each at the entry (Dalmia site) and exit (Perungudi site) of the mountain pass. In addition to above study, another study for validating the various CFD tools such as WindSIM, MeteoDYN,





Zephy etc., is also being carried out using the data collected from these wind monitoring stations. The expected project duration to complete the aforesaid would be 2 years. The outcome of the study would be useful for validating various wind forecast models particularly for that region, repowering in that particular location (it is ascertained that nearly 6000 old wind turbines are existing within the vicinity of this region) and also other research studies. In addition, a wind monitoring station was installed at Manalmelkudi site to understand the land side & sea side wind flow pattern and impacts. Data acquisition is under progress.

Wind Potential GIS Map for 120m and 150m level

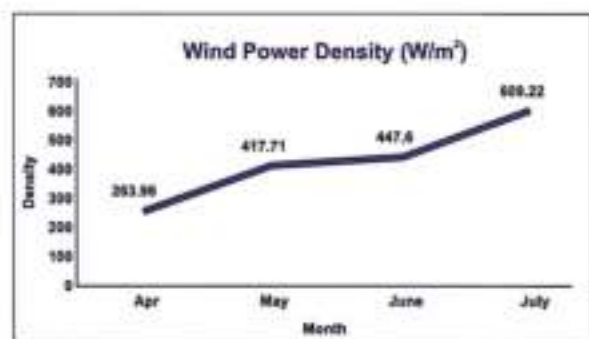
- 9.51 NIWE has assessed the wind potential within the country at 100m hub height with scientific rigor and based on authentic latest available data-sets, of wind as well as land, geologically spread across India. At present NIWE is in the process of extending the same scientifically rigorous methodology to estimate the indicative wind potential at 120m and 150m agl. With increasing hub heights, this indicative map would be a useful source for the wind farm developers and other stakeholders.

Offshore Wind Resource Assessment at Gulf of Khambhat, Gujarat

- 9.52 NIWE along with the support of ESSO-NIOT has established LiDAR-based offshore wind measurement structure near Pipavav in Gulf of Khambhat, Gujarat Coast at one of the zones identified by FOWIND. The remote sensing instrument LiDAR (Light Detection and Ranging) has been procured and installed in the Offshore platform on 31st Oct. 2017. Meanwhile, an additional Wind Monitoring Station or Automatic Weather Station has been installed on the platform. The measurements for a period of 2 years have commenced. The results of the analyzed data from the wind measurements by the Automatic Weather Station (AWS) / Wind Monitoring from April 2017. The data is continuously pushed by the AWS/WMS by the GSM communication to NIWE, Chennai. Data has been regularly analyzed and results are encouraging.



Monthly Average Wind Speed

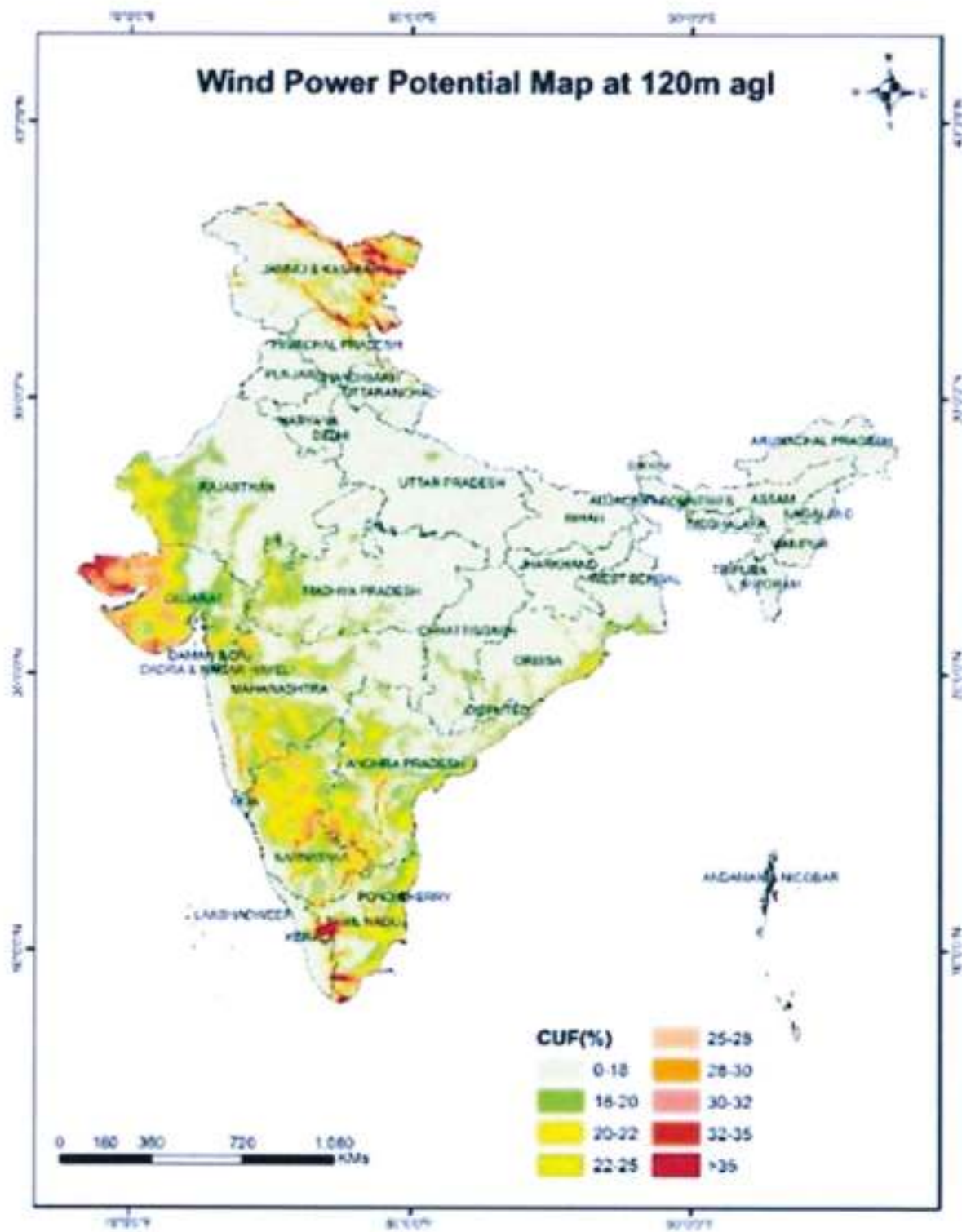


Monthly Average Wind Power Density

Geo-Tagging (on line registry) of Wind Turbines

- 9.53 NIWE is in the process of developing a geo-tagged data base / online registry of wind turbines installed across the country with the support of central and state agencies. At present, NIWE





120 m wind Atlas - Indicative map





is working to devise the methodology for the static data collection and suitable procedure / guidelines for dynamic data collection are also being developed.

TESTING & FORECASTING UNIT

Large Turbine Testing

- 9.54 During this year, Type Testing of XYRON 1000 kW wind turbine at Richadewda, Ratlam District, Madhya Pradesh of M/s. XYRON TECHNOLOGIES LTD through measurements have been completed as per the signed agreement. An agreement has also been signed between NIWE & M/s. Inox Wind Ltd., on 18th August, 2017 for Power Curve Measurements of INOX 2000 kW wind turbine with 113 meter rotor diameter at Ranipat Village, MuliTaluk, Surendranagar (Dist.), Gujarat. The measurement work is under progress.
- 9.55 An agreement has been signed between NIWE & M/s. Para Enterprises Pvt Ltd on 04th September, 2017 for Power Curve Measurements & Special Measurements for Loads of Pioneer 750 kW wind turbine W49-HH60 with 49 meter rotor diameter at HTSC no. 2988, SF. No. 95/4, 5&6B Part, Poigai Village, TenkasiTaluk, Tirunelveli District, Tamil Nadu. The measurement work is under progress.

Small Wind Turbine Testing

- 9.56 In addition to large wind turbine testing, NIWE is also giving its service in the small wind turbine domain. The work carried out for the small wind turbine are summarized below
- Type Testing assignment of model Vaata Smart, Vertical Axis WT (5.5 kW) at Karungulam of M/s. Vaata Smart Ltd has been undertaken.
 - Type Testing assignment of Nalwin 600 W at Wind Turbine Research Station, Kayathar, Tuticorin District, Tamil Nadu of M/s. Aparna Renewable Energy Sources Pvt.Ltd. has been undertaken.

Forecasting

- 9.57 The large scale integration of renewable energy calls for reliable forecasting and scheduling. It is also mandated by CERC and also other State Regulatory Authorities. NIWE has taken the pioneering step in forecasting of Wind energy with the support of Vortex, Spain. NIWE is also in the process of developing indigenous forecasting model. At present, the forecasting services is being given to SLDC TANTRANSCO under the agreement with IWPA.

Wind Turbine Test Station

- 9.58 NIWE has established a test facility at Wind Turbine Test Station (WTTS) near Kayathar in Tamil Nadu, where wind turbines are tested according to International Standards. WTTS is presently equipped to undertake Type Testing (TT) of wind turbines and to conduct the testing of wind turbines as per the requests of customers / manufacturers and the following tests are normally carried out as per International standards IEC 61400-12-1, 13, 1. The tests are also carried out at field sites subject to the site meeting the requirements of IEC Standards. WTTS was established with the technical assistance of Riso National Laboratory, Denmark under Danish International





Development Agency (DANIDA) grant and with partial financial assistance and guidance from the Ministry of New and Renewable Energy (MNRE), Government of India. The testing facilities are certified as per the requirements of ISO 9001:2008 and accredited as per the requirements of ISO / IEC 17025:2005.

WIND TURBINE RESEARCH STATION UNIT

Preventive and Breakdown Operation & Maintenance of Wind Electric Generators

- 9.59 It is also noteworthy to mention that NIWE has in-house capability for Regular Preventive and Breakdown Operation & Maintenance of turbines. As on date, NIWE has carried out renovation of its 28 years old first generation 200 kW MICON WEG'S (9 nos. of turbines installed in Kayathar).



Operation and maintenance

Grid Integration Solar PV with Wind Electric Generator on hybrid mode

- 9.60 The wind-solar hybrid is a new dimension in optimizing the available infrastructure and also to reduce the intermittency of these generation. In order to understand and offer research in this sphere, NIWE has commissioned 75 kW solar PV with one of the 28 years old under performing 200 kW MICON wind electric generator at WTRS, Kayathar. Research on this demonstration project is being carried out to understand optimization of connected grid capacity and flat power supply during peak wind season period by utilizing existing land, transformer, transmission line etc. The performance of the hybrid system was monitored during the windy season 2017. The mathematical modelling of the above integration of 75 kWp solar power with 200 kW wind electric generator is under progress.





DATA COLLECTION IN WIND SOLAR HYBRID SYSTEM @ WTRS, KAYATHAR

STANDARDS & CERTIFICATION AND R&D / S&T UNIT

9.61 During the year, NIWE has successfully undergone the first periodic audit and recommended for continuation of certification. NIWE has also successfully completed two type certification projects (Renewal) viz., V 39-500 kW with 47 m rotor diameter and Pawan Shakthi-600 kW. Renewed certificates have been issued to the respective wind turbine manufacturers. The following Certification Projects were taken up under NIWE -TUV Rheinland, Germany Co-operation:

- Inspection for the Manufacturing Evaluation at a wind turbine tower production unit.
- Evaluation of Grid Code Compliance of 2 MW wind turbines as per CEA Technical Standard.
- Witnessing of Safety and Function test and Personnel Safety assessment for a wind turbine model at the test site as a part of Type Certification.

INFORMATION TRAINING AND COMMERCIAL SERVICES UNIT

Training Programmes

9.62 This unit has conducted four International Training Course on wind energy wherein 76 International participants from 22 countries (Afghanistan, Argentina, Azerbaijan, Cameroon, Egypt, Ethiopia, Ghana, India, Iran, Jordan, Kenya, Mauritius, Myanmar, Nepal, Sri Lanka, Sudan, Suriname, Tanzania, Uganda, Vietnam, Zambia, and Zimbabwe) have been trained during this period with the sponsorship from the Ministry of External Affairs, Government of India under ITEC / SCAAP and AIFS – III programs.

NIWE participation in India International Science Festival (IISF) 2017 Exhibition

9.63 NIWE had participated in the Mega Science Expo by establishing stall with well-designed Information Panels showcasing the activities and services of NIWE to the visitors of India International Science Festival (IISF) 2017 during 13-16 October 2017 at Anna University by Ministry of Science & Technology, Ministry of Earth Sciences, Vijnana Bharathi and National Institute of Ocean Technology, Chennai.





Special International Training Course on Wind Turbine Technology & Applications specially for African countries

NIWE's Newsletter – Pavan

- 9.64 NIWE is publishing regularly a well received quarterly bilingual NIWE newsletter "PAVAN" [English and Hindi], which disseminates information about the activities & services of NIWE, wind energy news, technical articles and information on wind energy related events. During this period, 53rd (April-June) & 54th (July-September) issues have been published by ITCS unit and distributed among stake holders and the publication of 55th (October-December) and 56th issues will be published as per the schedule.

Visitors to the Campus

- 9.65 To create awareness and to motivate towards research on wind energy, and also to create awareness about the activities and services of NIWE, schools and college students are encouraged to visit the campus. During the period from April – December 2017, 353 students from 6 colleges and 130 students from 2 schools visited NIWE facilities at Chennai and 52 students from 2 University/college visited WTRS facility of NIWE at Kayathar and learned about Wind Energy through the presentations made by NIWE's Scientists and the showcasing of the renewable energy facilities available in the Campus. Also 99 training participants of other organizations have visited the facilities.

Global Wind Day Celebrations 2017

- 9.66 Global Wind Day is a worldwide event that is celebrated annually on 15 June and NIWE being the technical focal point for the development of wind energy in the country has been celebrating the Global Wind Day every 15th June since the year 2009. In this year's celebration held on 15th June 2017 at NIWE Shri. S. SubbaRao, Former Chief Scientist and Head, Information Division, Central Leather Research Institute, Chennai graced the occasion as the invited Chief Guest and delivered the commemorative lecture on the topic 'Global Wind Day'.





SOLAR RADIATION RESOURCE ASSESSMENT UNIT

- 9.67 MNRE has sanctioned a project for the establishment of nation-wide network of Solar Radiation Resource Assessment (SRRA) stations and an exclusive SRRA unit was established at NIWE. The following are the activities of SRRA Unit.
- Calibration of 18 Pyranometers & 9 Pyrheliometers from SRRA stations in the states of Andhra Pradesh, Karnataka, Kerala, Telangana, Madhya Pradesh & Assam were carried out under SRRA project.
 - MoU between NIWE and SLDC-GETCO, Gujarat for the development of indigenous Solar Power Forecasting model funded by PSDF through SLDC-GETCO, Gujarat was signed on 22.09.2017.
 - Short term training programme on Solar Energy for Mytrah Energy (India) Pvt. Ltd, Hyderabad was taken up in November 2017.
 - Establishment of 3 SRRA stations, one in Maharashtra and 2 in Kerala are likely to be established by March 2018.
 - Final data from 4 advanced measurement stations at Gurugram, Howrah, Thiruvallur and Gandhi Nagar as per BSRN format will be submitted to BSRN, Bremerhaven by March 2018 for uploading in their website.

Awards and Honours

- 9.68 Dr. G. Giridhar, Deputy Director General & Group Head, SRRA received Dr. K.C.G. Verghese Excellence Award on 29.07.2017 from the Hindustan Group of Institutions, Chennai.
- 9.69 Dr. P. Kanagavel, Additional Director, ITCS received Excellence in Teaching Award – 2017 conferred by Madras Library Association (MALA) on the occasion of the 125th Anniversary Celebration of Padmashree Dr. S. R. Ranganathan held at Indian Institute of Technology, Chennai on 12th August 2017.

SOLAR ENERGY CORPORATION OF INDIA LIMITED (SECI)

Introduction

- 9.70 Solar Energy Corporation of India Ltd. "SECI" is Section-3 Company under the Companies Act, 2013, with 100 percent Government ownership, under the administrative control of the Ministry of New and Renewable Energy (MNRE).
- 9.71 The company was set up as an implementing and executing arm of the Jawaharlal Nehru National Solar Mission (JNNSM) for development, promotion and commercialization of solar energy technologies in the country. In 2015, the mandate of the company has been broadened to cover all segments of renewable energy, pursuant to the approval of the Government of India.
- 9.72 SECI is active in the solar and wind energy segments presently, and undertakes wide ranging activities such as implementation of Government of India schemes, project development, consultancy, decentralised solar systems, power trading, R&D initiatives etc.





- 9.73 It is a profit-earning PSU and has registered a total revenue of Rs. 798.16 Cr. and net profit after tax (PAT) of Rs. 46.54 Cr. during Financial Year 2016-17.

Organization

- 9.74 SECI's Board of Directors is headed by Chairman and comprises of Managing Director, four functional directors and a Government nominee Director.
- 9.75 Shri Anand Kumar, Secretary, MNRE, is also Chairman of SECI, with effect from 17.07.2017 after taking charge from Shri Rajeev Kapoor. Shri J. N. Swain is the Managing Director, SECI, with effect from 01.08.2017, upon superannuation of Dr. Ashvini Kumar in July, 2017. Appointment to the posts of Director (Solar) and Director (PS) are awaited.

Achievement highlights for the year 2017-18

750 MW VGF Scheme under JNNSM Phase-II, Batch-I

- 9.76 SECI has implemented the first VGF scheme of 750 MW, under JNNSM Phase II, Batch I for setting up large scale ground-mounted solar PV projects on pan-India basis. After a transparent selection and award process, project capacity of 680 MW could successfully be commissioned and projects are under commercial operation. State-wise details of commissioned projects are given in the following table.

State	Capacity
Rajasthan	355 MW
Gujarat	40 MW
Maharashtra	25 MW
Madhya Pradesh	220 MW
Karnataka	10 MW
Tamil Nadu	10 MW
Odisha	20 MW
Total	680 MW

- 9.77 SECI has released VGF amount of Rs. 1.04 Cr. to developers in 2017-18 (till 31.12.2017) under the scheme.

2000 MW VGF Scheme of JNNSM Phase II, Batch III

- 9.78 The second batch of VGF scheme of 2000 MW capacity (JNNSM Phase II, Batch III) is under implementation by SECI. Tenders have been brought out on state-specific basis, either in solar parks being developed in the states or outside solar parks, where the same are not available.
- 9.79 Under this scheme, developers would be paid tariff of Rs. 4.43 per kWh or the discounted tariff discovered through e-reverse auctioning, for 25 years by entering into a PPA with SECI. Power from





these projects would be sold to various discoms/ Bulk consumers/state utilities by SECI at Rs.4.50 per kWh (including trading margin of 7 paisa per unit).

- 9.80 Under the scheme, PPAs have been signed for 2295 MW in 5 states. Out of this,390 MW has been commissioned and balance is under progress.

5000 MW VGF Scheme

- 9.81 On the lines of the 2000 MW VGF Scheme, another VGF scheme of 5000 MW capacity (Phase-II, Batch-IV) has been assigned by MNRE to SECI for implementation. This scheme provides for purchase of solar power by SECI from selected developers at a fixed tariff of Rs. 4.43 per kWh for 25 years and supply to Discoms at Rs. 4.50 per kWh. The projects are being set up either in the solar parks being developed by states or are non-solar park based.

- 9.82 Under the scheme, PPAs have been signed for 1720 MW across 4 states. 280 MW capacity has been commissioned and balance is under execution. Tenders have been issued for 3975 MW in 2017-18.

- 9.83 One of the major highlights of the scheme has been the discovery of lowest ever solar tariff of Rs. 2.44 per kWh, in the tender issued by SECI for Bhadla solar park in Rajasthan (in May, 2017) and the discovery of solar power tariff of Rs. 2.47-2.48 per kWh (in Dec, 2017, post introduction of GST).



10 MW Solar Power Project in Maharashtra

Scheme for 1000 MW Wind Power

- 9.84 SECI has been designated as the implementing agency by MNRE for implementation of the scheme for procurement of wind power on a pan-India basis. Till Dec, 2017, SECI has brought out tenders for 4000 MW (3000 MW in 2017-18), and aggregate capacity of 2049.9 MW has been awarded. The projects are under implementation.

- 9.85 The wind power tender is a unique endeavour on atleast two counts: firstly, it has heralded in the era of competitive procurement of wind power, that is expected to bring about rationalization of power tariffs and enhance competition in the industry; and secondly, that it has introduced large-scale inter-state transfer of wind power through the Central Transmission Utility (CTU) network, thereby allowing other than wind-rich states to avail the benefits of wind energy.

- 9.86 The tenders have resulted in discovery of record-low wind tariffs of Rs. 2.64-2.65 (in Oct, 2017).





Grid-connected Rooftop Programme

- 9.87 SECI has been successfully implementing MNRE's Solar Rooftop Schemes across the country, aimed at mitigating diesel consumption and savings in electricity procured from the Discom. Under this scheme, several rounds of open tendering have been carried out by SECI and out of 644 MW allocated, about 95.7 MW capacity has been commissioned across India under existing schemes. About 40.08 Cr. has been released as subsidy under these schemes in 2017-18 (till 31.12.2017).
- 9.88 SECI is operating rooftop solar tender (with 30% subsidy for general category States and 70% subsidy for special category States), in which, letters of award (LoA) were issued for a capacity of 292 MWp in the previous year. The scheme covers implementation of rooftop systems in Social, Residential, and Institutional sector. 7 MW capacity has been installed and balance capacities are under execution.
- 9.89 Letters of Award have been issued for 226 MW under the Grid connected rooftop tender (with 25% incentive for general category States and 60% subsidy for special category States) under the "Achievement Linked Incentive Scheme" for buildings in Government Ministries, Departments, Central and State and the scheme is in the process of implementation.



Grid connected solar rooftop plant of 170 kWp installed by SECI at Seth Anandram Jaipuria Education Society, Jaipuria Institute of Management, Indrapuram, Ghaziabad, Uttar Pradesh



500kWp solar Rooftop power Plant at MM Engineering College, Mullana, District Ambala, Haryana





Own Project Development

10 MW Jodhpur

- 9.90 SECI's first project under its ownership, commissioned in March, 2016, has been successfully under commercial operation. The project has generated 18.9 million units in 2016-17, corresponding to annual CUF of 21.61% on AC basis. In 2017-18, the CUF of the project has been 20.66% (till 30.09.2017).

1 MW Andaman & Nicobar (A&N)

- 9.91 This 1 MW rooftop solar project, spread over 13 buildings and supplying power to A&N administration under a long term PPA, has been installed in 2017-18. PPA has been signed at a tariff determined by the Joint Electricity Regulatory Commission (JERC). Project was commissioned in June, 2017.

160 MW Solar-wind hybrid project

- 9.92 For further development of SECI's portfolio, development of RE power projects using newer technology configurations and use applications, such as battery storage, floating solar etc. is under active consideration.
- 9.93 As an initial endeavour in this area, SECI is planning to set up a 160 MW of solar-wind hybrid power plant with battery storage in Andhra Pradesh, with World Bank financing. Project site has been identified and techno-commercial feasibility assessment of the project have been undertaken. Pre-tendering works are being undertaken.

10 MW at DRDO, Karnataka

- 9.94 A 10 MW project has been identified to set up at DRDO Kolar premises in Karnataka. The project will be developed by SECI on Build Own operate basis and the generated power will be sold to DRDO establishments in Karnataka under third party open access sale. An MoU was also signed with DRDO in this regard. Feasibility studies for power evacuation have been completed by KPTCL. Pre-tendering works are being undertaken.

Project Management Consultancy

- 9.95 Project Management Consultancy (PMC) is developed as an important revenue-generating activity of the company. SECI has taken up assignments on turnkey basis for a number of clients.
- **50 MW project at Kasargod, Kerala** : the project, owned by IREDA, is located in Kasargod solar park, Kerala. The project has been commissioned in September, 2017.
 - **16 MW at Medak, Telangana**: the project is being developed for for Bharat Electronics Limited in the state of Telangana. The plant has been synchronized in Oct, 2017.
 - **5 MW at Bhanur, Telangana**: A 5 MW plant is being for Bharat Dynamics Limited in Telangana. The project has been commissioned in Sept, 2017. A second project of similar capacity is under execution.
 - **Vizag Port (10 MW)** : SECI has taken up development of 10 MW solar plant in





Vishakhapatnam port. The project has been commissioned in May, 2017.

- **New Mangalore Port (4 MW) :** The project is located in the New Mangalore port premises, for meeting the captive power demand of the port. The project was commissioned in December, 2016.
- **5 MW at Pata, Uttar Pradesh :** SECI has provided PMC service for design, engineering construction, installation, testing & commissioning of India's second largest grid-connected rooftop power plant of 5.76 MW capacity at GAIL, Pata (Uttar Pradesh). The project has been commissioned in Dec, 2017.

9.96 Several other PMC assignments are being undertaken by SECI for prestigious clients. Notable among these projects are: Coal India (200 MW), UPJVN (200 MW), THDC (50 MW), Banaras Hindu University (8 MW), VO Chidambaranar Port (5 MW), MES- Meerut (2 MW), Kolkata Port etc.



Inauguration of 16 MW BEL project at Medak, Telangana by Hon'ble Ministry of Defence, Shri Arun Jaitley



4 MW New Mangalore Port Project

9.97 Further, SECI is also undertaking specialised projects, such as solar with battery storage etc. Notable among these are:





- **2X7 MW at Leh-Kargil** : The project comprises of grid-connected solar PV plants of aggregate capacity of 14 MW, with 3 hour battery storage, at different locations in Leh and Kargil. The projects are being developed under the Prime Minister Development Package for Jammu & Kashmir (PMDP). Tenders is likely to be issued shortly.
- **2 X 1.5 MW for MES Leh**-the projects are also being developed with battery storage. Pre-tendering activities are in progress.

Solar Parks

- 9.98 SECI has been designated as MNRE's agency for handling the scheme for development of solar parks (40000 MW), for providing infrastructural support for setting up of solar projects, such as developed land and power evacuation facility, to project developers. 37 solar parks totalling 21284 MW capacity have been granted administrative approval by MNRE (till Dec, 2017).
- 9.99 The parks are in various phases of development. 2,230 MW capacity has been commissioned, 3,165 MW capacity is under progress, 5,125 MW is under tendering and balance is in the DPR stage.
- 9.100 CFA of Rs. 292.06 Cr. has been released by SECI in 2017-18 (till 31.12.2017) for development of these parks.
- 9.101 The solar parks in Andhra Pradesh, Karnataka, Madhya Pradesh, Kerala, Uttar Pradesh and Himachal Pradesh are being implemented through JVCs of SECI with the state designated agencies. Details of the JV companies incorporated are given in Table below.

Details of the JV companies incorporated by SECI for Development of Solar Parks				
State	Park Capacity (MW)	Solar Park Implementation Agency	JV Partners	Location(s)
Andhra Pradesh	4000	Andhra Pradesh Solar Power Corporation Private Limited	SECI, APGENCO & REDCAP	Anantpur, Kadapa, Kurnool in Andhra Pradesh.
Karnataka	2000	Karnataka Solar Power Development Corporation Private Limited	SECI & KREDL	Tumkur in Karnataka.
Madhya Pradesh	2750	Rewa Ultra Mega Solar Limited	SECI & MPUVNL	Rewa, Neemach, Agar, Mandaur, Rajgarh, Shajapur, Chhatarpur, Morena in Madhya Pradesh.
Uttar Pradesh	600	Lucknow Solar Power Development Corporation Limited	SECI & UPNEDA	Kanpur Dehat, Mirzapur, Allahabad and Jalaun in Uttar Pradesh.
Kerala	200	Renewable Power Corporation of Kerala Ltd.	SECI & KSEB	Kasargod in Kerala.
Himachal Pradesh	1000	Himachal Renewables Ltd.	SECI & HPSEB	Pooh, Kibber, Hikkim, Hull, Losar in Himachal Pradesh.





CPSU Scheme

- 9.102 As a part of various Government initiatives, MNRE targeted CPSUs to motivate them to set up solar power projects. The target capacity of the scheme was 1000 MW and it envisaged to provide a CFA of Rs.1 Cr./MW and Rs.0.5 Cr./MW to CPSUs for developing solar power projects based on use of domestically manufactured solar cells/modules and domestically manufactured solar modules, respectively. SECI has been designated as the Nodal Agency for implementing this scheme. Out of 963.26 MW approved under the scheme by MNRE, 805 MW has been commissioned, 71.76 MW is under execution and 86.50 MW is under tendering/yet to be tendered. CFA of Rs. 53.44 Cr. has been released by SECI in 2017-18 (till 31.12.2017).

Canal Top/ Canal Bank Scheme

- 9.103 In order to explore alternative to land with a view to increase penetration of solar power, a pilot scheme involving Canal-top and Canal-banks scheme was launched by MNRE with a total capacity of 100 MW. SECI was designated as the Nodal Agency for implementation, and the role of the company has been to oversee the implementation of projects in various states and provide CFA based on progress related milestones. Projects are being developed in 8 states viz. Punjab, Uttar Pradesh, Uttarakhand, Gujarat, Andhra Pradesh, Karnataka and West Bengal. 69 MW has been commissioned and balance 31 MW is under execution.

Defence Establishments Solar Scheme

- 9.104 With a view to encourage defence establishments to set up solar power projects, the Ministry launched a VGF scheme with a total target capacity of 300 MW. SECI was designated as the implementing agency. In order to facilitate development of projects, SECI has been actively interacting with various organizations including Ordnance Factory Board, Military Engineering Services, Border Security Forces, Cantonment Boards and Air Force Stations, etc. Out of total sanctioned capacity of 356 MW, 20 MW has been commissioned.
- 9.105 CFA of Rs. 26.71 Cr. has been disbursed by SECI in 2017-18 (Till 31.12.2017).

Power Trading

- 9.106 SECI has a Category II Trading License from Central Electricity Regulatory Commission (CERC) to carry out power trading on pan-India basis. It is an active power trader, carrying out trading on both intra-state and inter-state levels. SECI trades in solar power generated from projects under VGF schemes of JNNSM. Over 3000 million units have been traded across 15 states from projects under the schemes mentioned (cumulative).

Information Technology

- 9.107 SECI has deployed a new responsive corporate website and has secure E-mail connectivity. In order to improve upon efficiency and bringing transparency in procurement processes, STQC certified e-tendering & e-auction system of Telecommunications Consultants India Limited is deployed.
- 9.108 The company has implemented a web based application to record and report scheduled solarpower for trading of solar power. A web-based portal for facilitating the processes between





the company and selected bidders under 500 MW solar rooftop scheme for institutions has also been recently implemented.

Human Resource Management

- 9.109 SECI total permanent staff was 69 (as on 31.12.2017). Codification of personnel policies by way of publication of a bilingual personnel Manual, was carried out, which has been appreciated by the Hon'ble Minister of State (I/c), PCNREM and it has also received Rajbhasha award. Keeping in line with the continuous efforts of the Human Resource department to propagate knowledge and skill enhancement, 54 employees were sent for various training programmes to enhance their competencies by acquiring new knowledge and getting acquainted with the latest developments in the renewable energy sector. The Industrial Relations during the year remained harmonious and peaceful. SECI contributed Rs. 29.01 Lakh to Swachh Bharat Kosh 'SBK' under CSR.

Equity support from Govt. of India

- 9.110 SECI has been set up with an Authorized Share Capital of Rs. 2000 Cr. and Rs. 354 Cr. has been released by the Govt. of India as budgetary support. During Financial Year 2016-17, a turnover of Rs. 798.16 Cr. and net profit after tax of Rs.46.54 Cr. have been registered. SECI has paid dividend of Rs. 13.96 Cr. to the Government for the year 2016-17.

Awards & Accolades:

- 9.111 SECI has received the CBIP Award for "Outstanding Contribution for Development in Renewables".
- 9.112 SECI has been conferred with the "50 Top PSU Organization with Innovative Practices" Award by Asia Pacific HRM Congress.

SARDAR SWARAN SINGH NATIONAL INSTITUTE OF BIO-ENERGY (SSS-NIBE)

- 9.113 Sardar Swaran Singh National Institute of Bio-Energy (SSS-NIBE) Kapurthala (Punjab), an autonomous Institution of the Ministry of New and Renewable Energy, Government of India, has taken various initiatives on Research, Brainstorming Consultations on Biogas Development, energy efficiency and training for promotion of bioenergy in the country during the current year. The 14th Finance Committee Meeting and 27th Governing Council Meeting of the Institute were held on 4th august, 2017, wherein were discussed the various issues including new initiatives for the current year. The major activities carried out by the Institute are as follows:

R&D Projects

- 9.114 Three R&D projects on Biobutanol production and Bioethanol and Platform Chemicals generation from lignocellulosic biomass, sponsored by the Department of Biotechnology (DBT), Science and Engineering Research Board (SERB) an autonomous body under the Department of Science and Technology, Government of India, are being implemented by the Institute. One research project on biofuel was completed.





Energy Efficiency Measures

- 9.115 The Institute initiated action on the concept of the 'Zero Energy Institute Building' in association with the Punjab State Council for Science & Technology, Chandigarh, who will carry out assessment of energy consumption and energy efficiency of the Institute. In addition, the Institute has proposed to set up a 400 KW Solar Roof Top Power Plant on its building for in-house consumption of electricity. The project is proposed to be implemented by SECI, New Delhi.

Bio-energy Alliance

- 9.116 'Bio-Energy Alliance' constituted at Sardar Swaran Singh National Institute of Bio-Energy, Kapurthala in 2017. The Bio-Energy Alliance (BEA) registered under the Societies Registration Act, 1860 with its registered office at SSS-NIBE. The main objective of the Alliance is to encourage networking between R&D institutions for joint projects between R&D institutions and industries for the development of bio-energy and biofuel technology.

Brainstorming Consultation Experts Meeting

- 9.117 The Institute, organized a day long "Brainstorming Consultation Experts Meeting on Biogas Development" on 23rd June, 2017 at NIBE, Kapurthala for discussion and preparing an Action Plan for R&D, Testing, Evaluation and Standardization of Biomass Energy Systems. Selected Experts in the subject from key RD&D/academic and industry were invited for participation in the meeting. The overall RD&D, technology validation, technology development package, testing, standardization, certification and training in bio-energy in general and biogas in particular was discussed in detail at the meeting. It was considered that Bioenergy needs to be given greater attention to make rural/urban area's energy efficient for their energy needs. Necessity of standards and protocols in all areas of Bioenergy was discussed. It was discussed that NIBE can play a key role in biomass resource assessment, technology validation, testing field evaluation, standardization and training for widespread promotion of bioenergy in the country.



Brainstorming Consultation Experts Meeting in 23rd June, 2017 at SSS-NIBE Kapurthala.



Demonstration of the R & D Projects at the Institute SSS-NIBE to experts of Brainstorming Consultation Experts Meeting, 23rd June, 2017





Training

- 9.118 A three days National Training Programme on Biogas and Bioenergy Technology is scheduled to be held on 7-9 March, 2018 for SNAs/ project developers/implementer and related stakeholders, including researcher for the promotion at SSS-NIBE, Kapurthala. The training will focus on design, development, installation performance evaluation, policy and financing aspects of biogas technology for cooking, power generation and transport applications.

Publications

- 9.119 SSS-NIBE, Scientists have published five research papers in National/International Journals, seven research papers published in the proceedings of National/International conference and seven chapters published in different books in this duration in the area of bioenergy.

INDIAN RENEWABLE ENERGY DEVELOPMENT AGENCY LIMITED

- 9.120 Indian Renewable Energy Development Agency Limited (IREDA) is a Mini Ratna (Category-I) Government of India Enterprise under the administrative control of Ministry of New and Renewable Energy (MNRE). IREDA is a Public Limited Government Company established as a Non -Banking Financial Institution in 1987 engaged in promoting, developing and extending financial assistance for setting up projects relating to new and renewable sources of energy and energy efficiency / conservation with the motto: "ENERGY FOR EVER".
- 9.121 During the Financial Year 2017-18 (up to 31.12.2017), IREDA has sanctioned loans to the tune of Rs.7500.72 Crore (corresponding previous year Rs.7027.20 crore) and disbursed Rs.5795 crore (corresponding previous year Rs.4850.35 crore) against the annual target of Rs.13,000 crore and Rs 8,100 crore for sanction & disbursements respectively. The above said sanctioned loan (includes co-financed projects/takeover loans) would support capacity addition of 1899.88 MW. The sector wise breakup of sanctions and disbursements for the said period are given below in Table:

Table: Sector-Wise Break-Up of Sanctions and Disbursements During the Year 2017-18 up to 31.12.2017 (Rs. in crore)		
Sector	Loan Sanction	Disbursement *
Wind Power	2496.09	2,024.34
Hydro Power	450.27	230.47
Cogeneration and Biomass	164.00	59.25
Solar Energy	3039.39	2,364.92
Bridge Loan	26.06	22.59
Bill Discounting	42.01	22.01
Energy Efficiency	0	0
Miscellaneous (STL+ Manufacturing + Waste to Energy+ NCEF+ Guarantee Scheme)	1282.89	1,071.58
TOTAL	7500.72	5,795.16

*It includes the amount sanctioned by IREDA during the financial year 2016-17





- 9.122 The sector-wise break-up of cumulative sanctions and disbursements up to 31.12.2017 is given in the table below:

Table : Sector-Wise Break-Up of cumulative Sanctions and Disbursements up to 31.12.2017 (Rs. in crore)		
Sector	Cumulative Loan Sanction	Cumulative Disbursement
Wind Power	22128.69	14,044.60
Hydro Power	7955.62	4,213.56
Cogeneration and Biomass	5271.89	3,338.13
Solar Energy	14111.36	6,972.81
Bridge Loan	122.76	141.53
Bill Discounting	75.11	55.12
Energy Efficiency	1271.10	339.58
Miscellaneous (STL+ Manufacturing + Waste to Energy+ NCEF+ Guarantee Scheme)	5396.06	4480.00
TOTAL	56332.60	33,585.33

MoU with MNRE

- 9.123 Based on the audited accounts of financial year 2016-17, the Memorandum of Understanding (MoU) rating is "Excellent". IREDA has also signed MoU with the MNRE for the year 2017-18.

Resource Mobilization

- 9.124 Paid up capital of IREDA is Rs.784.60 crore with a net worth of Rs.2652.44 crore based on the audited accounts for the period ended September 30, 2017. During April-December, 2017, IREDA has successfully raised Rs. 1950 Crore (approx. USD 300 Million) from Off-shore market by way of the issue of Masala Bond.
- 9.125 The Company has spent Rs. 4.60 crore during the FY 2016-17 on CSR activities (including ₹2.94 Crore paid for the projects which were sanctioned during the year 2016-17). Projects aggregating to ₹7.05 Crore were sanctioned and in progress of completion at the end of the financial year 2016-17. The unspent amount on CSR initiative shall be spent upon the completion of the project. During the year, the Company has undertaken CSR initiatives in the fields of environmental sustainability including contribution to Swachh Bharat Kosh, Skill Development, Rural Development, Electrification of Community Areas, provided benefits to the armed forces widows and their dependents.

