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EDITORIAL

A successful showcasing of wind power forecasting and scheduling by NIWE sponsored by IWPA has proven significant improvement of evacuation of more wind energy close to meeting about 10,000 million units in a day in Tamil Nadu. This also indicates an increase of 26% more grid availability for wind power evacuation. Another major feet by TANGEDCO may be stated as Inter-State sale of excess wind power to Northern India.

The wind industry with a release of wind-solar hybrid policies, NIWE's comprehensive study at 24 windy sites (100 m tall tower measurement sites) has a proven evidence of realizing the 175 GW potential with 100 GW solar and 60 GW wind as a one to one complementing hybrid energy. The study at NIWE shows that at any given windy site of the 24 locations one MW of wind and one MW of solar can give a net renewable energy in the grid with 61% share from wind and 39% share from solar. It may be observed that even though complementary in nature, wind is seasonal (May to October) & Solar is distributed over 300 days.

The wind industry even though has added only about 1300 MW so far is confident of reaching about 4000 MW by the end of the FY 2016-17.

There is a definite need to go for component testing in the case of new forms of wind turbine blade development using comprehensive International quality blade testing facility, entire drive train testing of wind turbines evolving cost effective component designs (mechanical as well as power electronic). As per the CEA technical standards for grid interfacing, all the wind turbines which are grid connected need to be certified for LVRT features (low voltage ride through) and harmonics.

NIWE as Member of the RLMM Committee constituted by MNRE, Govt. of India is rigoursly taking efforts to implement as guided by SRPC (Southern Regional Power Committee) the required LVRT compliance. This necessitates capacity building of LVRT field testing at NIWE for which efforts are being taken.

With regards to the progress in various Units of NIWE, the fabrication of LiDAR support platform for Gulf of Khumbat has been in progress and the various required permissions for installation commissioning of the same is also being pursued.

NIWE has implemented a customized SCADA for remote monitoring of energy generation at WTRS Kayathar through a Consultancy executed by CSIR/CSIO. More than 37 wind monitoring stations are operated in 11 States, 18 sites wind resource have been verified, AEP estimation for 119 MW have been completed, due diligence and power curve energy calculation have been done respectively for 100 MW and 30 MW. Micrositing, wind power forecasting and scheduling has been actively continued by NIWE.

A one day technical workshop on small wind energy and hybrid system as applicable to telecom tower powering has been completed. Type testing and data analysis are in progress for two wind turbines, power curve measurement for one wind turbine and a site feasibility study are in progress at wind turbine testing.

A renewed certificate has been released to RRB and suggestions of SRPC has been implemented in RLMM. NIWE is happy to announce that 3 S&C engineers have been recognized as certification experts by DAkkS, Germany based on their credentials.

Wind Solar Hybrids intelligent convertor system have been established at Kayathar and a new 2 MW DFIG model INOX wind turbine erection has been completed.

One International Training Programme has been completed during the period. Several student visits have been under taken both in Chennai and Kayathar campus.

Independence Day celebration was illuminated at NIWE, as directed by MNRE.

Four training programmes have been organized by SRRA and micro-siting visits were being carried out for Solar Projects.

5 TTTs (Technology Think Tank series) lectures, DigSILENT training, Internships with 15 UG students and 5 PG students, SWS empanelment, RC Meeting are noteworthy activities during the period.

Scientist and Officials delivered several invited lectures and also made a few publications and secured an Award.

NIWE would invite active Industry sponsorship and participation in developing the visionary, research infrastructure at NIWE to meet the growing needs of base level designs in the Wind Industry.

We thank you for your support and constructive suggestions.

Dr. S. Gomathinayagam, Director General

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Editorial Board

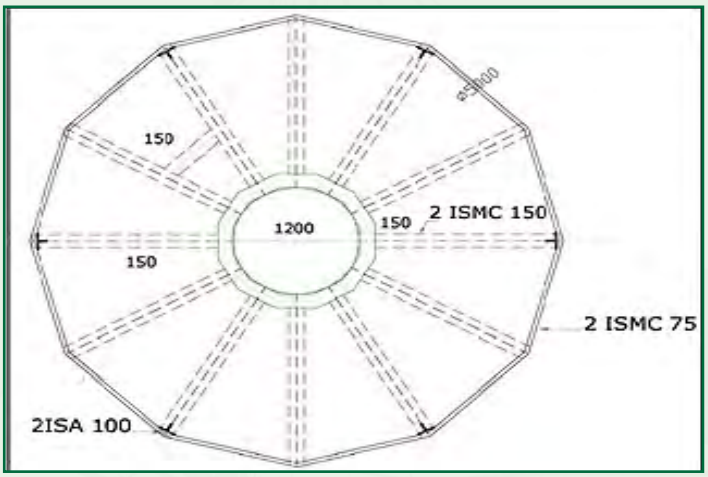
Offshore Wind & Industrial Business

i) Observation platform for mounting LiDAR

NIWE is in the process of establishing monopole platform in the sea for assessing the offshore wind using LiDAR based measurements at Gulf of Khambhat, off Gujarat coast. The platform has two components, superstructure (Support Platform) and substructure (Monopile). The superstructure platform was designed for self-weight and these loads are transferred to design monopile.

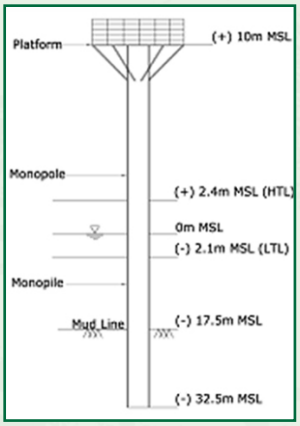
The platform is made of central circular beams supported on monopile. The primary beams are radially connected to central beam, where the ends are connected with ring beams to support the mounting plates. All the required equipment like wind LiDAR, wind measurement instruments, power supply unit and batteries will be supported on these plates.

The fabrication work for monopile and the support platform is in progress and is likely to be installed and erected by mid of November 2016 at Gulf of Khambhat, Gujarat.



Layout of support platform

Gujarat - Latitude 20° 41' 30" N and Longitude 71° 32' 50" E



Conceptual layout of Sub-structure for mounting LiDAR

ii) First LiDAR based offshore wind resource validation efforts launched by NIWE in India

NIWE seeks to overcome the lack of long-term wind resource data availability in offshore location by initiating the first such effort in Indian territorial waters. The 'FOWIND' supplied LiDAR was calibrated against an existing 120 m met mast at Kayathar NIWE installation at the identified offshore platform location at Gulf of Khambhat, Gujarat - Latitude 20° 41' 30" N, Longitude 71°32'50" E.

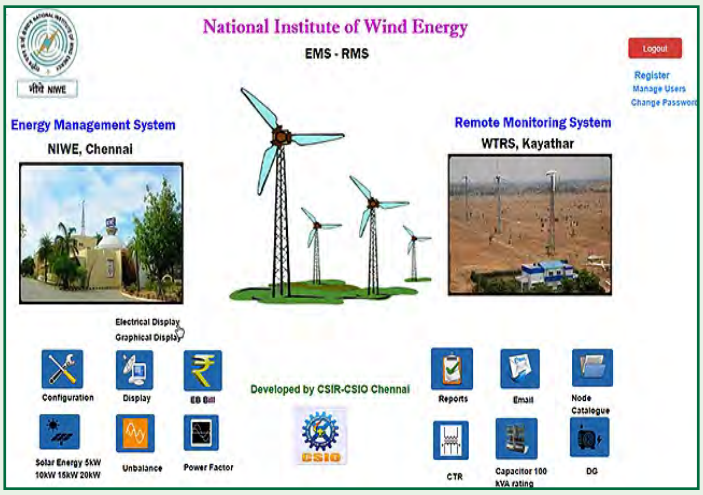
iii) Geophysical and Geotechnical Surveys and Studies

NIWE proposes also to conduct geophysical and geotechnical surveys and studies both off Gujarat and Tamil Nadu coasts to better understand the subsea profile data. The geophysical / geotechnical studies will cover the entire Zone 'A' as per the FOWIND report. The geotechnical surveys will be carried out at required locations of sea bed up to a depth of 30 m in soil or 10 m in rock after the successful completion of geophysical investigation.

Tamil Nadu - Latitude 8°.25'.00" N and Longitude 78°.12'.00"

iv) Remote Monitoring of Energy generation at WTRS, Kayathar and Integration with Energy Management System at NIWE, Chennai

NIWE has executed through a consultancy project to CSIR-CISO for development and installation of customised Energy Management System (EMS) in its Chennai Campus, including the remote data collection from the wind turbines installed at Wind Turbine Research Station (WTRS), Kayathar. The EMS has been successfully installed at NIWE, Chennai and has total of 17 sensor nodes. The system is under observation and is based on the data acquired from EMS, the report evaluation and analysis is in progress. Thereafter, the integration of Remote Data Monitoring software with the EMS software will be undertaken.



NIWE – EMS – RMS DISPLAY FRONT-END

Wind Resource Assessment

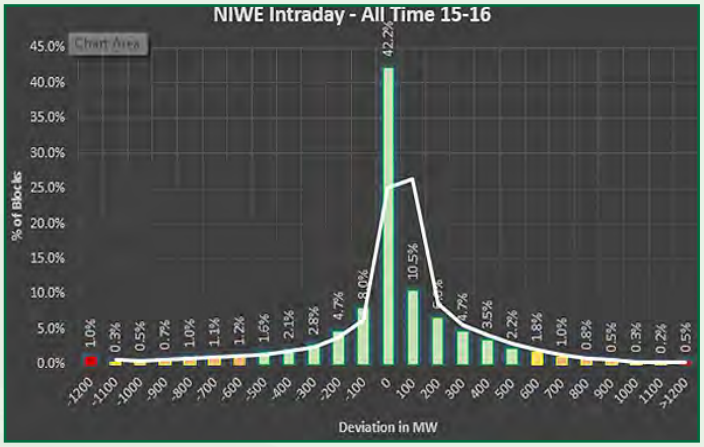
During the period of July to September 2016, 1 Wind Monitoring Station was commissioned in Tamil Nadu and 8 Wind Monitoring Stations have been closed down (1 in Telangana, 1 in Pondicherry, 3 in Uttar Pradesh & 3 in Andhra Pradesh). Presently, 37 wind-monitoring stations are operational in 11 States under various wind monitoring projects funded by the Ministry of New and Renewable Energy (MNRE) as well as various entrepreneurs.

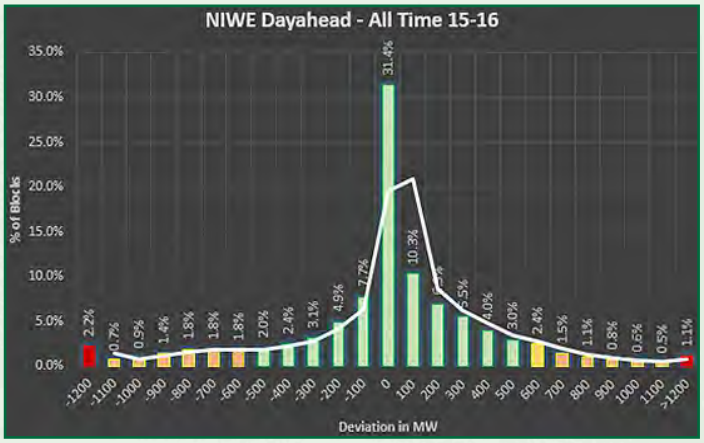
The following consultancy projects have been completed and reports have been submitted during this period:

- Verification of procedure of wind monitoring for 18 sites.
- Site validation & Generation Estimation for the proposed 119 MW wind farm.
- Technical Due Diligence of the proposed 100 MW wind farm.
- Power Curve Energy Demonstration (PCED) test for existing 30 MW wind farm.
- Micrositing & Annual Energy Estimation of the proposed 16 MW wind projects.

Wind Power Forecasting services

- Prepared generic approval for extension for Wind Power Forecasting Services for another one year, now including scheduling.
- Work order issued to M/s.Vortex.
- Coordination with M/s.Vortex to refine the forecast substation wise is in progress.
- Establishment of secondary forecast system for continuous service is in progress.
- Preparation of project proposal for providing Wind Power Forecasting services to M/s.Bhoruka Power Corporation Ltd., Bangalore is in progress.
- Completed Secondary stand by forecast system for continuous service was successfully established in NIWE.





Forecast Graph

- Preparation of final report on Wind Power Forecast service for the year 2015-16 to M/s.IWPA is in progress.
- Based on the successful completion, on Wind Power Forecasting M/s.IWPA has extended project for one more year, including scheduling.

WRA in Uncovered / New Areas 2016-17

Site selection has been carried out in the state of Telangana and Assam.

R&D Projects progress in WRA

- Installed 50m tubular mast at Perungudi TNPL wind farm area to conduct a Research Study on the influence of mountain pass on wind flow and its impact on the power generation at Entry & Exit points of Muppandal Pass for validating the CFD tools.
- SODAR rectification has been carried out.
- Site selection work installation of Small Wind Turbine has been completed.
- Site visit has been carried out at Nagarcoil for Aralvaimozhi Pass effects.

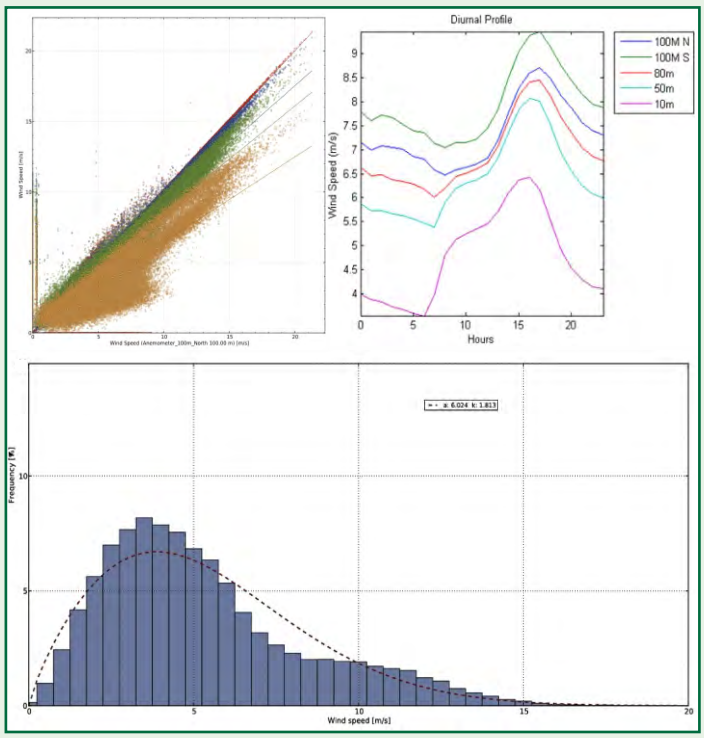
Estimation and Validation of WPP at 100m Level

NIWE established 75 (10 in Andhra Pradesh, 12 in Gujarat, 12 in Rajasthan, 13 in Karnataka, 8 in Maharashtra, 8 in Madhya Pradesh and 12 in Tamil Nadu) Wind monitoring stations under the project 'Estimation & Validation of Wind Power Potential at 100m level in 7 States of India' and the data acquisition is in progress.

- One year continuous data acquisition from 69 WMS (10 in Andhra Pradesh,12 in Gujarat, 4 in Madhya Pradesh, 7 in Maharashtra, 13 in Karnataka,11 in Rajasthan and 12 in Tamil Nadu) and two year continuous data from 48 WMS (11 in Karnataka, 1 in Madhya Pradesh, 6 in Gujarat, 11 in Tamil Nadu, 4 in Maharashtra, 9 in Andhra Pradesh & 6 in Rajasthan) has been completed successfully.
- Continuously monitoring and receiving the real time wind data from 20 stations with 100m met masts in 7 States.
- Monthly Data Analysis, Verification and preparation of Interim reports are in progress.
- Dismantling of Sensors and Mast from 55 WMS of 100m tall are in progress.

Wind Resource Assessment Studies

- Final report for M/s.NEEPCO has been sent.
- Preparation of draft report for 1 site in Karnataka for M/s.NTPC has been carried out.



Monthly Data Analysis

- Closedown of 1 site in Tamil Nadu for M/s.Ennore Port has been carried out.
- Interim report for 1 site in Karnataka for M/s.NTPC has been sent.
- Interim report for 1 site in Gujarat for M/s.Kandla Port Trust has been sent.
- Interim report for 4 sites in Assam for M/s.Oil India has been sent.

Other Programmes

- R.Vinodkumar, Junior Engineer carried out site selection in Tirunelveli, Nagercoil & Kanyakumari for relocation of 100m mast for Wind Power Forecasting on 1st & 2nd July 2016.
- K. Boopathi, Additional Director & Head carried out site selection for the project Relocating 100m mast for validating Wind Power Forecasting at Trichy, Tamil Nadu on 14th July 2016.
- Demonstration of Data Loggers by the bidders has been convened at NIWE, Chennai on 15th July 2016.
- Standing Technical Committee (STC) Meeting towards procurement of met masts & its accessories, Instruments was convened at NIWE, Chennai on 20th July 2016.
- Meteodyn (CFD based Wind Flow Modelling) software training was conducted for NIWE Scientists and Engineers at NIWE, Chennai on 21st July 2016.

- Review Committee Meeting on Bird Migration Study to discuss about the progress has been convened at NIWE, Chennai on 2nd August 2016.
- Special Training programme on Wind Resource Assessment and Wind Energy Technology for SNA officials was organized at NIWE, Chennai during 22nd to 26th August 2016.
- A follow up meeting on implementation of WRA on telecom towers has been convened at NIWE, Chennai on 9th September 2016.
- Technical Committee meeting for finalization of technical specification of LIDAR was arranged at NIWE, Chennai on 15th September 2016.

Special Training Course

In order to create awareness among the SNA officials regarding the importance of Wind Resource Assessment & Wind Turbine Technology a special Training Course on "Wind Resource Assessment & Wind Energy Technology for SNA officials except NE region was organized from 22nd to 26th August 2016 at NIWE, Chennai.

The prime objective of this training course is to transfer knowledge and needed skills to the officials from State Nodal Agencies / departments for effectively implementing the wind power projects and Renewable Energy technologies in their respective States.

Chief Guest inaugurating the course

The training started on 22nd August 2016 which was inaugurated by Prof. Dr. K. Kasthurirangaian, Chairman, Indian Wind Power Association.

The training course was attended by 18 participants from 9 States (Karnataka, Jammu & Kashmir, Chhattisgarh, Rajasthan, Telangana, Kargil, Maharashtra, Kerala and 1 Union Territory Pondicherry) and the course was highly appreciated by the participants for its intellectual level and the way of organization. The 5 days programme included classroom lectures, onsight demonstration, field and practical training sessions at Kayathar & Kanyakumari wind farms to provide complete knowledge transfer to the participants.

The training was concluded on 26th August 2016 with the Valedictory function chaired by Dr. M.V. Ramana Murthy, Scientist-G & Head, NIOT and Guest of Honour by Shri. Sven Ruin, Project Manager, TEROCAB, Sweden.

Distribution of Course Certificate to Participants

One day Technical Workshop on Small Wind Energy and Hybrid Systems & its relevance to Telecom Towers

NIWE organized a one day technical workshop on “Small Wind Energy and Hybrid Systems & its relevance to Telecom Tower” with the support of Maharashtra Energy Development Agency (MEDA), Government of Maharashtra on 1st July 2016 at Pune. The workshop was inaugurated by Hon'ble Secretary, MNRE along with Joint Secretary, MNRE, Director General, MEDA, Director, GEDA and Director General, NIWE, Chennai.

Workshop Overview and its Relevance

Small wind turbines and Small Wind Energy–Solar hybrid systems are becoming more popular worldwide. These systems can play a major role in the decentralized energy generation and its utilization and can potentially reduce the pressures on centralized generation systems and transmission and distribution networks. Presently, a small annual market (a few hundred kilowatts) for small wind and wind–solar hybrid systems exist in the country. The market is driven mostly by the capital subsidy programme of the MNRE, Government of India. The potential market for renewable-energy-based micro–generation as per a tentative study is estimated at around 83,000 MW. This takes into context applications in rural and urban decentralized electrification, Telecom towers, part-load replacement of diesel-based captive power plants.

Telecom Sector is a promising stakeholder for implementation of renewables. The telecom towers are

Hon'ble Secretary Inaugurating the Workshop with Joint Secretary

energy intensive and require uninterrupted DC power for operation. On an average, the country's telecom tower network consumes over 11 billion kWh annually and is likely to increase up to 17 billion kWh by 2016. In the absence of grid or intermittent power supply where the grid is available, these telecom towers are powered by diesel Generators. As a result, the telecom sector consumes around 3 billion litres of diesel annually for powering these towers. Need of the hour is to reduce the Carbon footprint and the cost of operation in this sector. On an average, even if, 50 % of the mobile towers shift to renewable power from diesel, the cost saved would run into hundreds of crore annually. Presently, about 4,40,000 numbers of telecom towers are installed in India. Out of this, about 1,93,000 towers are connected to the grid and the rest depends on diesel during power outages eventhough the communication transmitters mainly need a DC supply through battery bank.

Hence, in order to understand the available options for the reliable supply of power to these towers from RE specifically from SWES systems (Small/ Wind-Solar Energy Systems), an one day workshop was organized by NIWE.

The workshop provided an invaluable platform for dialogue and open exchange of views and experiences between the policy makers and the targeted stakeholders. The workshop focused on some of the major issues that concerns the Small wind power industry and the telecom tower operators who are the second largest diesel consuming sector in India next only to Railways. The workshop gave a comprehensive overview of the technical, financial and policy solutions presently available in India and brainstormed for finding innovative solutions. This aims to bring together all Indian Stakeholders under one roof for a day to have fruitful discussions and was a grand success.

The workshop saw attendance in good numbers from Small Wind Turbine manufacturers, SWES system integrators, Solar Channel partners, Telecom tower operators including a few RESCOs and SNA's like Maharashtra, Gujarat, Goa, Chhattisgarh, Tamil Nadu, Meghalaya, Manipur and Sikkim. Exhibits of Small Wind Turbines were also showcased as part of the workshop. The stalls saw a lot of erudite discussion between the invitees from educational institutions and the targeted stakeholders.

During the workshop, Hon'ble Secretary, MNRE had released 20m (above ground level) wind speed map of India. Further, the GIS based map was also made available at NIWE's website for the public to utilize the information and facilitate the project developers to identify appropriate places / sites for the effective implementation of the SWES projects.

Further, during the inaugural function, various SNA's, small wind turbine manufacturers, SWES system integrators, etc. were felicitated with appreciation awards / certificates by Hon'ble Secretary, MNRE for their outstanding contribution in the promotion / implementation of Ministry's SWES programme.

The workshop had the benefit of hearing from various subject experts from the field of policy making, Small wind turbine, Telecom sector, batteries and inverters.

Wind Turbine Testing

- Type Testing of XYRON 1000 kW wind turbine at Richadewda Ratlam District, Madhya Pradesh of M/s. Xyron Technologies Ltd. The measurements process is in progress.
- Type Testing of INOX 2000 kW wind turbine at Kidi village , Babra Taluk, Amreli District, Gujarat of M/s. INOX WIND LTD. The final test reports issued to the customer and the project has been closed.
- Power Curve Measurements of REGEN 1500 kW wind turbine at Vagarai Village, Dindigul District, Tamil Nadu near Dharapuram of M/s. ReGen Powertech Pvt. Ltd. The final test reports issued to the customer and the project has been closed.
- An agreement was signed between NIWE and M/s. TUV NORD INDIA for Site Feasibility Study (SFS) for Site Calibration / Power Curve Measurements of 1700 kW wind turbine at Badval, Cuddapah District, Andhra Pradesh.

Standards and Certification

- An agreement has been signed with M/s. RRB Energy Limited to take up the project on renewal of certificate of "Pawan Shakthi – 600 kW" wind turbine model as per TAPS-2000 (amended). Carried out review / verification of various documentation in connection with renewal of certificate of Pawan Shakthi – 600 kW wind turbine model. Based on the review / verification, renewed certificate has been issued to M/s. RRB Energy Limited.

Issuing renewed Certificate to M/s. RRB Energy Limited

- Successfully undergone the DNV recertification audit conducted by DNV-GL as per ISO 9001:2008.
- Presently, authorization has been issued to all the three S&C Engineers as Certification experts of NIWE – TUV Rheinland by accreditation body viz., DAkkS, Germany, based on the credentials and experience.
- As suggested by Southern Regional Power Committee (SRPC), Bangalore, issued Corrigendum - 1 dated 27.07.2016 in connection with modification of the Title of TABLE-A2 of the 'RLMM - Consolidated Addendum – II List dated 10.06.2016' to various stakeholders including State Electricity Boards, TRANSCOs, and State Nodal agencies etc. Further, the same has been hosted at NIWE website.
- Review / Verification of documentation provided by various wind turbine manufacturers for more than 50 wind turbine models in connection with the release of Revised List of Models and Manufacturers of wind turbines (RLMM) – Main List is in progress.
- Shri. A. Senthil Kumar, Director & Head, S&C attended two meetings of the MNRE committee held at MNRE, New Delhi to discuss and suggest the methodology / protocol to be followed including the list of documents required towards enlisting of Wind Turbine Generator (WTG) manufacturers / models by MNRE as per the provisions of the draft guidelines for onshore wind energy development.
- Interactions with officials of TUV Rheinland (India) Private Limited & M/s. TUV Rheinland Industrie Service (TUVR) GmbH in connection with certification co-operation works are ongoing.
- Co-ordination works with Bureau of Indian Standards (BIS) and members of working group on standards in connection with preparation of draft Indian standards & review of draft IEC documents on wind turbines are ongoing.
- Co-ordination with wind turbine manufacturers in connection with documentation to be submitted as per MNRE guidelines on prototype wind turbine models after issue of letter in connection with grid synchronization of prototype wind turbines are ongoing.
- The continual improvement and maintaining the quality management system are ongoing.

Wind Turbine Research Station

- All the 9 200 kW MICON Wind Electric Generators in WTRS, Kayathar were put in for un-interrupted operation during the windy season 2016 with timely and sustained Operation & Maintenance works.
- Works on installation of Grid integration of 75 kWp Solar PV Power with Existing 27 years old 200 kW Micon WEG @WTRS, Kayathar completed for best use of existing infrastructure like Land, Transformer, Transmission lines etc.
- Installation works of Micro Thruster Augmented in 200 kW MICON available at WTRS, Kayathar by VIT, Vellore in respect of Trial run on fixing of micro thruster at the tip of the one blade is carried out successfully and fixing on other blades under progress. Works on modification / fabrication in the low speed shaft of WEG in fixing the mechanical seal for the flow of compressed air to the micro thruster through blade under progress.
- Works on erection of 2000 kW DFIG Model INOX Wind Electric Generator at WTRS, Kayathar has been Completed and Transmission electrical line works in progress.

Visitors:

The following visits were coordinated and showcased the Small & Large Wind Turbine Testing, R&D and WRA facilities:

- 60 Students and 3 staff from Varatharajan Polytechnic, Perambuloor , Tamil Nadu visited on 22nd July 2016.
- 19 Students and 1 staff from Anna University, Chennai, Tamil Nadu visited on 24th July 2016.
- 23 officials from various State Nodal Agencies, for Training programme on "Wind Resource Assessment and Wind Turbine Technology" visited on 26th August 2016.
- 30 Delegates of 18th International Training Course on "Wind Turbine Technology and Applications" visited on 31st August 2016.

Erection of 2000 kW DFIG INOX WEG @ WTRS, Kayathar

Installation of Micro Thruster Augumented at kW

Grid Integration of 75 kWp SOLAR PV with 200 kW WEG @ WTRS Kayathar

MICON WEG at WTRS, Kayathar by VIT, Vellore

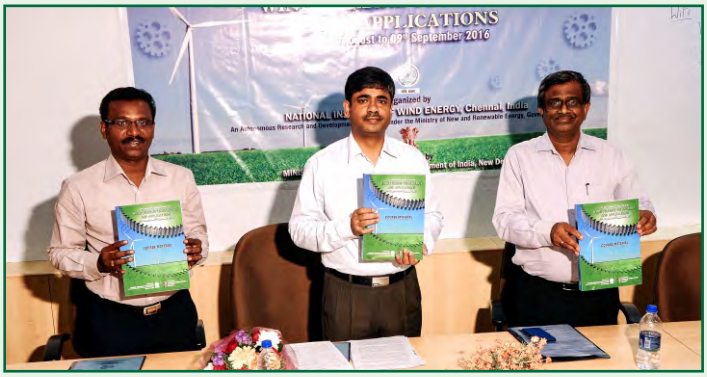
Information, Training and Customized Services

18th International Training Course (24 days)

Successfully conducted the 24 days 18th International Training Course on "Wind Turbine Technology and Applications" during 17th August to 9th September 2016 addressing all aspects of Wind Power starting from introduction to wind and its technology, wind resource assessment, installation, operation and maintenance aspects of wind farms along with financial analysis and CDM benefits. This is a special training course for ITEC / SCAAP partner Countries sponsored by the Ministry of External Affairs (MEA), Government of India under ITEC / SCAAP programme. The course was attended by 30 Participants from 20 countries (Afghanistan, Azerbaijan, Democratic Republic of Congo, Egypt, Ethiopia, Gambia, Ghana, Guyana, Iran, Jordan, Lesotho, Malawi, Myanmar, Nepal, Nigeria, Poland, Sudan, Tanzania, Tunisia, Vietnam).

The training was inaugurated by Prof. Santosh Kapuria, Director, CSIR-Structural Engineering Research Centre (SERC), Chennai

During the 24 days of training, 46 classroom lectures were scheduled, which were handled by NIWE scientists and external experts, Wind Turbine Manufacturers, Wind Farm



Release of Course Material

and Developers, Consultants, Academicians, Utility and IPPs To provide complete knowledge transfer, arrangement were made for practical training at NIWE Laboratories, study visit to (i) M/s. ReGen Powertech, TADA (ii) Wind Turbine Test Station, Kayathar (iii) Wind Turbine Research Station, Kayathar (iv) Wind Farms of various models, make and capacity (v) M/s. Suzlon CMS, Radhapuram (vi) M/s. Apollo Electrical Works, Kavalkinaru (vii) M/s. RS Wind Tech, Aralvoimozhi (viii) Wind Farms in and around Kanyakumari for knowledge on various working wind turbines.

Shri. V. Viswanathan, Associate Vice President, Special Projects - India, TUV India Private Limited was the Chief Guest for the Valedictory Function and distributed the course certificates to the all the participants.

Chief Guest distributing the Course Certificate to the participants

NATIONAL TRAINING COURSES				
S.No.	Description	From	To	Duration
1.	20th National Training Course on "Wind Energy Technology"	07.11.2016	11.11.2016	5 Days
2.	21st National Training Course on "Wind Energy Technology"	20.03.2017	24.03.2017	5 Days
INTERNATIONAL TRAINING COURSES				
S.No.	Description	From	To	Duration
1.	Special Training Course on for Uganda Officials on "Wind Resource Assessment & Wind Farm Planning"	07.11.2016	18.11.2016	10 Days
2.	Special Training Course on "Wind Turbine Technology and Applications" for Africa Countries under AIFS-III	23.11.2016	16.12.2016	24 Days
3.	19th International Training Course on "Wind Turbine Technology and Applications" for ITEC / SCAAP for Partner Countries	01.02.2017	28.02.2017	28 Days

Student Visits

To create awareness and to motivate towards research on wind energy, achieving the indigenization 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 July 2016 to September 2016, the following visits were coordinated.

- 72 students & 4 staff of Ellen Sharma Memorial Matriculation Higher Secondary School, Sholingallur on 8th July 2016.
- 24 delegates of National Institute of of Technical Teachers Training & Research (NITTR), Taramani, Chennai on 27th July 2016.

Students Internship

The following foreign students training fellowship applications have been processed under different scheme.

Research Training Fellowship for Developing Country Scientists (RTF-DCS)

1. Mr. Tchodou Samah B from Directorate General for Energy, Ministry of Mines and Energy, Togo
2. Mr. Tinotenda Zvavashe from National University of Science & Technology, Zimbabwe.
3. Ms. Nogoye Diaw from Fann Hock, Senegal.

Indian Science and Research Fellowship (ISRF)

Dr. Thi Thi Soe from Mynamar has joined NIWE for the research work in solar.

Engineering Services Division

- NIWE Twitter page has been updated to manage social activities of NIWE (www.Twitter.com/niwe_chennai).

NIWE Official Twitter Page

Independence Day Celebrations

- NIWE campus was illuminated on the eve of Independence Day celebration.

Civil Works

- Construction work of Security Guard room near entrance main gate has been completed.
- Construction of additional two wheeler shed near to the lift room has been completed.
- Construction of front side sump platform work has been completed.
- Construction of flooring and fixing of tiles at Driver cabin work has been completed.

General Maintenance Works

- The Secretary, MNRE has dedicated NIWE to the Nation on 18th February 2016. In this connection, the fabrication of Inscription stone Installation work needs to be done. Request has been placed and the Approval has been received during this September 2016 and the work is in progress.
- Work order is yet to be issued for Lawn mower with regard to Gardening work.
- 5 kW Hybrid wind solar system – small 3.2 kW wind turbine repair work is in progress.
- Reclamation work for car parking at front yard work is in progress.
- Re installation of Solar Water pump at the rear side of the SRRA cabin is in progress.
- Water proofing coverage work for SRRA Cabin at the rear side of the building has been completed.

Solar Radiation Resource Assessment

1. Micrositing visits carried out at :
   - i) Raipur 1 MW SPV plant of CREDA for relocating Bilaspur SRRA station.
   - ii) Chandrapur (Govt, Engg. College) for establishing SRRA station under MEDA Consultancy Project.
   - iii) Parbhani (Agricultural University) for establishing SRRA station under MEDA Consultancy Project.
   - iv) Badi Sid for relocating the Bodana / Phalodi SRRA station to the 10 MW SECI SPV plant at Badi Sid.
2. Quality Controlled data of 7 (Seven) SRRA stations were supplied under SDSAP policy.
3. Calibration of 10 pyranometers were carried out under commercial mode.
4. Signed MoU with St. Xavier Catholic College of Engineering on 12th August 2016 in connection with Academic, R&D and Collaborative activities.
5. SRRA brochure released by Director General, NIWE on 15th August 2016 during the Independence Day celebration.
6. Tender evaluation of EOI for solar forecasting held on 1st & 2nd September 2016.

Training/Workshop

1. 6 days training programme on Solar Energy conducted on designing of Solar Power Plants, DPR, financial analysis of solar plants and solar software, such as, PVsyst and SAM by M/s. Steinbeis Solar Centre, Chennai at NIWE, Chennai during 16th to 23rd June 2016.
2. A training programme on “Stand alone PV System: Design and installation” carried out under PPP mode through M/s. GSES, New Delhi during 18th -22nd July 2016.
3. A training programe on Solar Forecasting on SRRA with GIZ was held at NIWE, Chennai on 20th August 2016.
4. A Solar Software training programme on INSEL and TRNSYS by M/s. Steinbeis, Chennai at NIWE, Chennai on 14th & 15th September 2016.

Knowledge Sharing and Management & Small Wind Energy Hybrid System

Technology Think Tank

NIWE strives to create a culture of transparent knowledge sharing and one of the directives is the Technology Think Tank (TTT) series lectures on thursdays.The following technical topics were presented on every Thursday during the period:

S.No.	Date	Dept.	Name	Topic of the Presentation
1	14-07-2016	KS&M	Mr. V. Sandeep	Breathing New Life into Old Wind Turbines
2	21-07-2016	SRRA	Dr. Jeyraj Selvaraj	Renewable Energy Scenario in Malayasia
3	28-07-2016	WTT	Mr. M. Saravanan	NIWE Code for Fatigue Load Spectra Analysis AS PER IEC/TS 61400 - 13
4	04-08-2016	ITCS	Ms. D. Chandralekha	Mapping and Integration of Renewables for better utilization
5	11-08-2016	SRRA	Mr. K. Raj Kamal	Solar PV Technologies

Technology Think Tank (TTT) lecture in progress

Grid Modelling for Integration of Renewable - Prep-work

Indian Utilities are seeing an increased deployment of Solar & Wind power to meet the demands of the grid and these renewable assets provide large portions of electricity generation during some periods of the year. Utilities need support vide modelling of the Gird to understand wind power's possible impacts on electric power system operations, because wind's

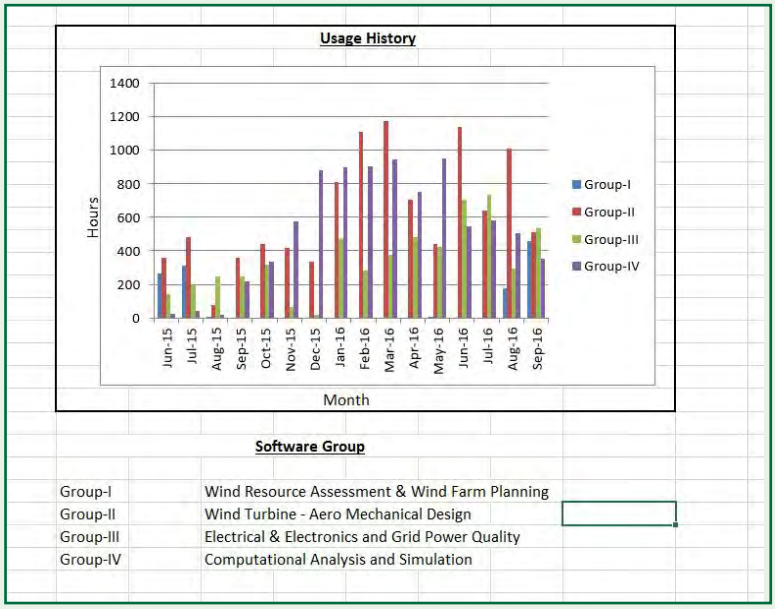
One week in-house training on "DIgSILENT" is in progress

variability or infirmity which adds uncertainty beyond what is present level of variations in electricity demand or load. These requirements if properly addressed would open a wide canvas in the grid penetration for renewables and safe ingress of large quantum of wind power in India. The training on PowerFactory to institute's scientists and engineers will help create a core group which will become active in modelling such systems and understanding the scenarios better, and supplemented by field data from the research wind farm, the results can be validated further.

A one-week exhaustive training cum hands on has been organised during 26th to 30th September 2016 for NIWE staff to be trained in the industry grade modelling software "DigSilent PowerFactory". The training gave a whole some view on modelling the grid with renewables and the analysis to ensure various grid code related compliances and other strategies.

Work Group – a Soft Skill Platform

NIWE has established a work group of scientists, engineers and trainees with a bouquet of Industry grade software shared by various operating units of the Institute to cross train the institute's personnel in multi-softskills and also to groom one another in various facets of its usage for the common goal of achieving the targets of the institute. The usage history of software by the different groups has given in the following graph and is summarised as follows:



Software Group

Group-I	Wind Resource Assessment & Wind Farm Planning
Group-II	Wind Turbine - Aero Mechanical Design
Group-III	Electrical & Electronics and Grid Power Quality
Group-IV	Computational Analysis and Simulation

Internship & Projects for Students

Infusing fresh ideas and thoughts in the conventional work block can be achieved only when new bearers of ideas come in. Interns and Project students are that fresh wisp of air an institute needs. Currently NIWE has about 15 UG students and 5 PG students pursuing final year project mentored by various resource persons supporting from the units of NIWE. Some of the works of interest are energy storage scenario for WTRS farm, out-of-the-box blade designs to name a few. Students from some of the major universities of Tamil Nadu work with us at NIWE. Also MNRE has approved the provision of stipend for Interns and soon full-fledged ads for such positions will be placed in web public domain to attract talents at NIWE.

Small Wind Energy Hybrid System

NIWE acts as a harbinger of good tidings for the SWT/ SWES industry and provides some of the most accurate testing services in the Asia-Pacific region at the most affordable costs possible. Tested machines and models with valid type certificates are listed for facilitating the subsidy program of the ministry. The 14th List of SWT Empanelment has been released in NIWE webpage on 27th September 2016 subsequent to the committee meeting held in the 2nd week of September 2016 at NIWE, Chennai. This list has the largest number of Grid tied operable models ever populated in the list, an marvellous achievement in itself, and a standing testimony to NIWE's patronage for the swt technology ingress in the Indian landscape.

Research and Development Council

The 24th Research Council of NIWE was organised on 12th September 2016 at NIWE, Chennai under the Chairmanship of Shri. SK Soonee, CEO, Power System Operation Corporation Limited, POWERGRID. The newly reconstituted RC in its first meeting has shown a great desire to give a new direction to the research outreach of the institute and bring under its radar all the researchers active in wind energy in India to create a critical mass to tilt the balance in favour of a sustainable research environment in India. The wise counsel of the RC has invigorated the resolve of the institute to be the centre of synergy and coordinate with wind researching institutes and end the siloed operation of research prevalent with few academic institutions.

Invited lecture delivered / meeting attended by NIWE Official in external forums

Dr. S. Gomathinayagam, Director General

- Attended the SWES workshop at Pune on 1st July 2016.
- Chief Guest for the International Seminar on "Renewable Energy Systems" at Hindustan University, Padur on 26th July 2016.
- Attended the Dashboard Meeting with Hon'ble MoS (I/C) for Power, Coal, NRE and Mines at New Delhi on 30th July 2016.
- Review of Birds Study Meeting at Chennai on 2nd August 2016.
- Attended the GC of NISE at New Delhi on 3rd August 2016.
- Attended the FC of NIWE at MNRE, New Delhi on 4th August 2016.
- Attended Steering Committee Meeting of 2nd Renewable Energy Global Investors meet & Expo – REINVEST 2017 at New Delhi on 11th August 2016.
- Attended the Meeting on New Development Bank at New Delhi on 16th August 2016.
- Attended the 1st Meeting of R&D Sectoral Project Appraisal Committee (RDSPAC) at MNRE on 19th August 2016.
- Attended the Meeting with USA delegates to discuss and pursue the US-India Bilateral Cooperation initiatives at MNRE chaired by Secretary on 29th August 2016.
- Attended the Standing Committee on Energy at Parliament House – Role of PSUs/Institutions under MNRE in the development of RE Schemes on 30th August 2016.
- Presentation before Hon'ble Minister on Draft guidelines for Development of Onshore Wind Power Projects on 19th September 2016.
- Attended Technical Committee Meeting on "Performance Evaluation Unified SRRA Project" at NIWE on 30th September 2016.

Dr. Rajesh Katyal, Deputy Director General and Head, OW&IB

- Delivered a lecture on "Offshore wind turbine technology and the activities carried out by NIWE to three Assistant Secretaries from MNRE at NIWE, Chennai on 29th August 2016.
- Keynote Address and presentation on India's offshore Wind Policy and plans from MNRE at "Engineers training workshop on offshore wind project development" to be organized by FOWIND at Bangalore on 31st August 2016
- Delivered a lecture on "Small Wind Turbine Hybrid Systems" at one-day National Wind Energy Technical Symposium in the 10th Renewable Energy India Expo 2016 organized by NIWE and UBM at India Expo Centre, Greater Noida on 8th September 2016.

Dr. G. Giridhar, Deputy Director General & Head, SRRA

- Attended meetings with MNRE & SECI officials regarding solar forecasting on 21st July, 2016 and National Wind-Solar Hybrid Policy Committee Meeting at SECI, New Delhi on 22nd July 2016.
- Attended Standing Committee Meeting with MNRE officials on "Energy" at New Delhi on 31st August 2016.
- Attended Seventh meeting of the Interim Administrative Cell of International Solar Alliance (ISA Cell) on 7th September 2016.

A. Mohamed Hussain, Deputy Director General & Head, WTRS

- Lecture delivered on "Over view of Testing/R&D/WRA facilities at WTRS/WTTS, Kayathar during visit of Delegates of 18th International Training Programme participants to WTRS, Kayathar on 31st August 2016.
- Lecture delivered on "Over view of Testing/R&D/WRA facilities at WTRS/WTTS, Kayathar during visit of Officials from various State Nodal Agencies for Training programme on Wind Turbine Technology and Application at Kayathar on 26th August 2016.
- Lecture delivered on "Wind Solar Hybrid system " during the conference conducted by India Infrastructure Publishing Private Ltd. New Delhi on 22nd September 2016.

S.A. Mathew, Director & Head, WTT

- Invited to chair R&D Meeting (Electrical & Electronics Engineering) and the idea of the meeting is to give opportunity to professors to present their innovative research proposals held at Veltech Dr. RR & Dr. SR Technical University, Chennai on 3rd July 2016 .
- Attended the meeting on "Draft Guidelines for Development of Onshore Wind Power Projects" held at MNRE on 28th July 2016.
- Attended the 2nd meeting on "Draft Guidelines for Development of Onshore Wind Power Projects" held at MNRE on 19th September 2016.
- Attended the Re-Certification Audit –ISO 9001:2008 by DNV-GL held at WTTS, Kayathar on 5th August, 2016 and at NIWE, Chennai on 8th August, 2016.

A. Senthil Kumar, Director & Head, S&C

- Presentation on S&C unit services to the 3 Assistant Secretaries (I.A.S. officers) during their visit to NIWE to acquaint themselves with the NIWE activities on Wind & Solar on 29th August 2016.
- Delivered a lecture on "Type Certification of Wind Turbines" aat one-day National Wind Energy Technical Symposium in the 10th Renewable Energy India Expo 2016 organized by NIWE and UBM at India Expo Centre, Greater Noida on 8th September 2016.
- Attended the 24th Research & Development Council (RC) meeting held at NIWE, Chennai on 12th September 2016.

M. Anvar Ali, Director & Head, ESD

- Coordinated the field visit of participants of the special training course on "Wind Resource Assessment and Wind Energy Technology" at WTRS, Kayathar & Kanyakumari held during 22nd to 25th August 2016.
- Co-ordinated the International participants of 18th International Training Course for field visit & Ayyanaruthu SS real time monitoring & explain Wind Farm Grid evacuation facilities at WTRS, Kayathar & Kanyakumari during 30th August to 3rd September 2016.

J.C. David Solomon, Additional Director & Head - KSM & SWES

- Attended first Industrial Advisory Board (IAB) Meeting to Syllabus for the academic year 2016-2017 at Saveetha School of Engineering, Saveetha University, Thandalam Campus on 2nd July 2016.
- R&D efforts of NIWE elaborated for the benefit of "Energy Research Centre" at BS Abdur Rahman University, Vandallur and invited to be academy partner in research on 3rd August 2016.
- Coordinated the field visit of participants of the special training course on "Wind resource assessment and Wind Energy Technology" at WTRS, Kayathar & Kanyakumari held during 22nd to 25th August 2016.
- Attended an International conference at "Renewable Energy Integration" jointly organised by IWPA & TANGEDCO, Chennai on 22nd & 23rd September 2016.

K. Boopathi, Additional Director & Head, WRA

- Attended meeting/discussion on Wind Resource in the state of Assam with Additional Chief Secretary, Power Department, Assam at Guwahati on 16th July 2016.
- Attended Committee Meeting on Wind-Solar Hybrid Policy at MNRE, New Delhi on 22nd July 2016.
- Attended Committee Meeting in connection with Guidelines for development of Onshore Wind Power Project at MNRE, New Delhi on 28th July 2016.
- Attended National Conference on Energy Data – Management, Modeling & GIS Mapping and has given presentation on GIS usage in Wind Energy at New Delhi on 10th August 2016.
- Attended Standing Committee Meeting at MNRE, New Delhi on 30th August 2016.
- Attended one-day National Wind Energy Technical Symposium in the 10th Renewable Energy India Expo 2016 organized by NIWE and UBM at India Expo Centre, Greater Noida on 8th September 2016.
- Participated in the Tamil Nadu Renewable Energy Integration International Conference at Chennai on 22nd & 23rd September 2016.
- Site inspection work has been carried out to find new location for near shore mast at Kanyakumari during 28th September to 2nd October 2016.

Dr. P. Kanagavel, Additional Director & Head, ITCS

- Attended first Industrial Advisory Board (IAB) Meeting to Syllabus for the academic year 2016-2017 at Saveetha School of Engineering, Saveetha University, Thandalam Campus on 2nd July 2016.
- Delivered lecture in the Training Programme on Energy Efficiency for NITT Scholars on "Renewable Energy (Solar & Wind) at National Productivity Council (NPC), Chennai on 15th July 2016.
- Delivered a lecture on "Overview of Wind Energy" at Vel Tech University, Chennai on 9th August 2016.
- Delivered a lecture on "Wind Energy - The Power for Future" at Highway Research Station, Chennai on 9th August 2016.
- Coordinated the field visit of participants of the special training course on "Wind resource assessment and Wind Energy Technology" at WTRS, Kayathar & Kanyakumari held during 22nd to 25th August 2016.
- Attended the 4th Fraunhofer Innovation and Technology Platform at New Delhi on 1st & 2nd September 2016.
- Delivered a lecture on "Wind Energy Development in India and Role of NIWE" at one-day National Wind Energy Technical Symposium in the 10th Renewable Energy India Expo 2016 organized by NIWE and UBM at India Expo Centre, Greater Noida on 8th September 2016.
- Attended the Meeting of the Governing Council of 'Skill Council for Green Jobs (SCGJ)', New Delhi on 16th September 2016.

M.Joel Franklin Asaria, Additional Director, ITCS

- Delivered lecture in the Training Programme on Energy Efficiency for NITT Scholars on "Renewable Energy (Solar & Wind) at National Productivity Council (NPC), Chennai on 15th July 2016.
- Co-ordinated the International participants of 18th International Training for field visit & Ayyanaruthu SS real time monitoring & explain Wind Farm Grid evacuation facilities at WTRS, Kayathar & Kanyakumari during 30th August to 3rd September 2016.

A. Hari Baskaran, Deputy Director, KSM & SWES

- Attended "Research and Development Sectoral Project Appraisal Committee (RDSPAC) of the MNRE, as a special invitee to review and evaluate the R&D Projects received by the Ministry under the thrust areas of "Small Wind Energy & Hybrid Systems".

Deepa Kurup, Deputy Director, KSM & SWES

- Attended an International conference at "Renewable Energy Integration" jointly organised by IWPA & TANGEDCO, Chennai on 22nd & 23rd September 2016.

A.G. Rangaraj, Assistant Director (Technical), WRA

- Attended SOLAR forecasting meeting at NIWE, Chennai on 3rd August 2016.
- Attended the meeting organized by IWPA in connection with forecasting & scheduling of wind power in Tamil Nadu at Coimbatore on 7th & 8th September 2016.
- Attended Integration International Conference at Chennai on 22nd & 23rd September 2016.

J. Bastin, Assistant Director (Technical), WRA

- Attended 1st ESRI India Regional User Conference 2016 (RUC) and Exhibition at Hyderabad on 4th August 2016.
- Attended the Tamil Nadu Renewable Energy Integration International Conference at Chennai on 22nd & 23rd September 2016.

M.R. Gunasekaran, Executive Secretary, KSM & SWES

Attended 2 days ArcGIS Developer Summit and User Conference Regional Meet at Hyderabad on 3rd & 4th August 2016.

3rd meeting on LVRT

Dr. S. Gomathinayagam, A. Senthil Kumar, S. Arulselvan have participated in the 3rd meeting on LVRT for compliance of orders of Hon'ble CERC in respect of petition no.420/MP/2014 and other provisions of CEA/CERC regulations at TANTRANSCO office, Chennai on 5th July 2016.

19th Management Review Meeting

S.A. Mathew, A. Senthil Kumar, M. Saravanan, Bhukya Ramdas, S. Arulselvan and S. Paramasivan have attended 19th Management Review Meeting of Quality Management System for ISO 9001:2008 held at NIWE, Chennai on 26th July 2016.

38th GC Meeting & 19th AGM

Dr. S. Gomathinayagam, A. Senthil Kumar, K. Boopathi have attended the 38th Governing Council meeting of NIWE held at MNRE on 20th September 2016.

Publications

Dr. P. Kanagavel, Human Resource Development in Wind Energy – India and Trainings conducted at NIWE, Bi-monthly Magazine-IWTMA, India Wind Power Vol. 2, Issue 3, August - September 2016.

Awards

Dr. P. Kanagavel has been awarded the **"Ariviyal Kalanjiyam (Eminent Scientist) Award"** confered by MTS Academy (Mylai Thiruvalluvar Tamil Sangam), Chennai on 11th September 2016. The Award received from Honourable Justice Shri. A.K. Rajan former Judge, Madras High Court of Chennai.

The following NIWE staff delivered lecture(s) in the 18th International Training Course on "Wind Turbine Technology & Applications" held during 17rh August to 9th September 2016

S.No.	Topic	Speaker
1	Introduction and Status of Wind Energy Technology Wind Turbine Tower	Dr. S. Gomathinayagam
2	Wind Resource Assessment and Techniques	Shri. K. Boopathi
3	Guidelines for Wind Measurements	Shri. A. G. Rangaraj
4	Wind Data Measurements and Analysis	Smt. G. Arivukkodi
5	Wind Measurements by Remote Sensing Instruments	Smt. M.C. Lavanya
6	Overview of Wind Turbine Components	Shri. J. C. David Solomon
7	Wind Turbine Generators	Shri. M. Anvar Ali
8	Control and Protection System in Wind Turbine	Shri. S. Arulselvan
9	Wind Turbine Foundation Small Wind Turbine Testing and Hybrid Systems	Dr. Rajesh Katyal
10	Design and Layout of Wind Farms	Shri. J. Bastin
11	Type Certification of Wind Turbine and Overview of Design Requirements as per IEC 61400 - 1	Shri. A. Senthilkumar
12	Wind Turbine Testing & Measurement Techniques	Shri. S. A. Mathew
13	Instrumentation for Wind Turbine Testing	Shri. M. Saravanan
14	Safety and Function Testing Power Curve Measurements	Shri. Bhukya Ramdas
15	Offshore Wind Energy	Shri. M. Joel Franklin Asaria
16	Wind Energy Development in India and Role of NIWE	Dr. P. Kanagavel
17	Indian Government Policies and Schemes	Shri. Mohammed Hussain
18	Forecasting of Wind and Energy Production	Shri. A. G. Rangaraj
19	Grid Integration of Wind Turbine	Smt. Deepa Kurup
20	Solar Radiation Resource Assessment	Shri. R. Karthik

The following NIWE staff delivered lecture(s) in the "Wind Resource Assessment Program" on 22nd August 2016

S.No.	Topic	Speaker
1	History of Wind Energy Conversion Technology and Power Generation including Small wind turbine	Dr. S. Gomathinayagam
2	Wind Resource Assessment & Techniques	Shri. K. Boopathi
3	Small Wind Energy & Hybrid Systems	Dr. Rajesh Katyal
4	An overview on 100m & 20m Wind Atlas and its application	Shri. J. Bastin
5	Introduction of NIWE Wind Farm Facility	Shri. A. Mohamed Hussain
6	Discussion on wind turbine components	Shri. J.C. David Solomon
7	Wind Measurement & Instrumentation	A. Hari Bhaskaran
8	Measurement parameters & Wind data analysis	Shri. Suresh Kumar
9	Wind Farm Planning Activities	Dr. P. Kanagavel
10	An overview of wind power forecasting	Shri. A. G. Rangaraj
11	Solar Radiation Resource Assessment	Dr. G. Giridhar / Shri. R. Karthik
12	Environmental Impact Study and Economic analysis	Shri. Joel Franklin Asaria

Newsletter of NATIONAL INSTITUTE OF WIND ENERGY, Chennai pavan Issue-50, July - September 2016

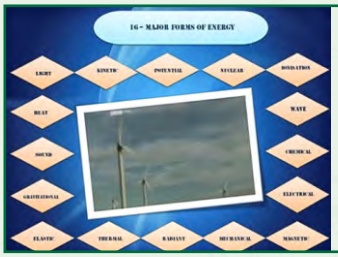
ENERGY STORAGE SYSTEM (ESS) – AN OVERVIEW

M.R. Gunasekaran, Executive Secretary-II, KSM & SWES, NIWE, Chennai E-mail : gunasekaran.niwe@nic.in

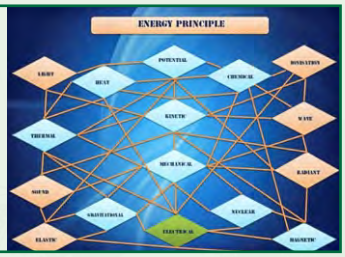
Introduction on Energy

The 18th Century energy scenario were determined by the energy demand owing to booming industrial activities. On the otherhand, the optimum utilisation of fossil fuel were in peak due to fulfilment of the raised demands. There is a global prediction that the future humanity will face serious problems by energy demands during 2050, because of the present energy usage predominant around the world[1]. The energy usage has already been increased by 85% between 1970 and 1999 and the consumption will triple by 2020. Also, the energy revolution estimated on the basis of prosperity of oil in the 20th Century to be 14 terawatts energy through 210 million barrels of oil equivalent per day. In 2050, the requirement will meet 30-60 terawatts energy through 450-900 million barrel of oil equivalent per day. The 21st century will face severe scarcity of fossil fuel; it will cause big transition into the renewable energy sector[2].

The word "energy" can be found in minimum 16 different formations [3]. However it can be classified as chemical energy, electrical energy, heat (thermal energy), light (radiant energy), mechanical energy, and nuclear energy. The law of conservation of energy states that the total amount of energy in a system remains constant ("is conserved"), although energy within the system can be changed from one form to another or transferred from one object to another. Energy cannot be created or destroyed, but it can be transformed, with or without associated losses.



Forms of Energy



Energy Principle

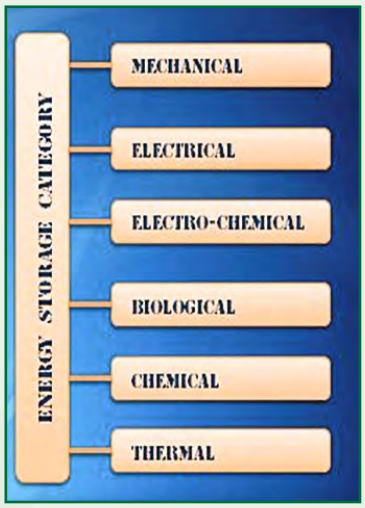
Energy Storage System (ESS)

Energy storage is the capture of energy produced at one time for use at a later time. A device that stores energy is sometimes called an accumulator. Energy comes in multiple forms including radiation, chemical, gravitational potential, electrical potential, electricity, elevated temperature, latent heat and kinetic[4].

Need for the system

Energy storage system indicates various reasons for their common needs, i.e.,

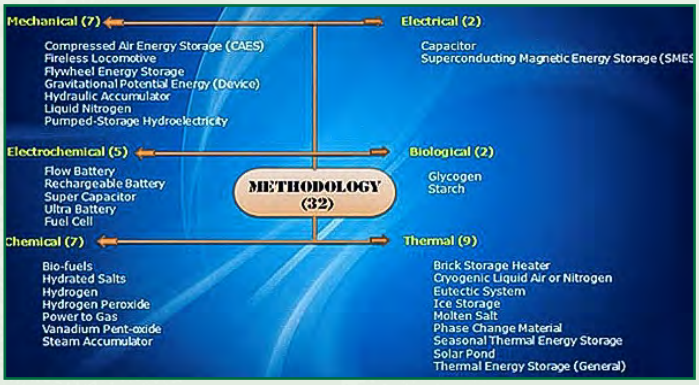
- Opportunities for storage increase as grid modernization efforts move forward
- Energy storage offers unique value to states with fully realized renewables
- The Clean Power Plan may turn storage into a matter of compliance
- Commercial facilities will also deploy storage to address peak energy consumption and more commercial storage deployments
- Diversified power generation and a more sustainable industry
- A more reliable power grid and project deferment
- Reduce Peak Demand Prices and take Advantage of Tax Incentives
- Avoid the High Costs of Generation and reduce Dependency On Weather
- Prepare for the Smart Grid
- Energy storage is likely to lower the costs of having a micro-grid or going off-grid, by islanding.
- Energy storage helps make the grid more reliable and affordable.



Type ESS

- Governments around the world are starting to mandate and incentivize energy storage.
- Energy storage helps developing countries enable widespread access (24x7) to electricity.

The key characteristics of storage systems needs to be analyzed before implementation for a particular application on requirement basis. The actual requirement may be determined by the application, form of output of the energy either electricity or thermal heat, size of the energy in MW, discharge duration, the cycling period and response time.



Methodology of ESS

Mechanical Energy Storage System [5]

Compressed air energy storage (CAES) is a way to **store energy** generated at one time for use at another time using compressed

air. At utility scale, energy generated during periods of **low energy demand** (off-peak) can be released to meet **higher demand** (peak load) periods.

Application: Air Car, pneumatically operated equipment and Steam Locomotive

A **fireless locomotive** is a type of locomotive which uses reciprocating engines powered from a reservoir of compressed air or steam, which is filled at intervals from an external source. They offer advantages over conventional steam locomotives of lower cost per unit, cleanliness, and decreased risk from fire or boiler explosion; these are counterbalanced by the need for a source to refill the locomotive, and by the limited range afforded by the reservoir.

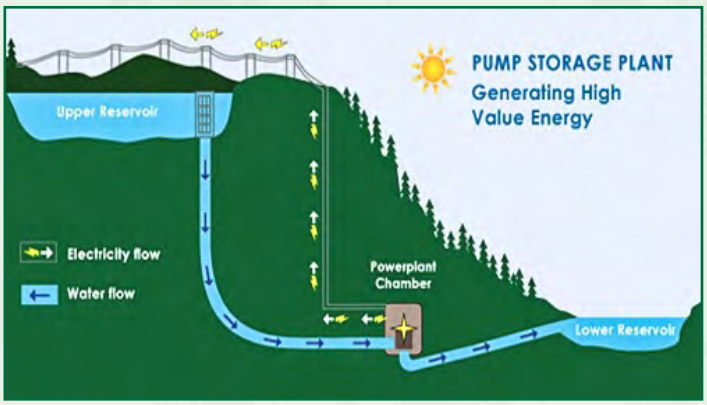
Flywheel energy storage (FES) works by accelerating a rotor (flywheel) to a very high speed and maintaining the energy in the system as rotational energy. When energy is extracted from the system, the flywheel's rotational speed is reduced as a consequence of the principle of conservation of energy; adding energy to the system correspondingly results in an increase in the speed of the flywheel.

Gravitational potential energy is **energy** an object possesses because of its position in a **gravitational** field. The most common use of **gravitational potential energy** is for an object near the surface of the Earth where the **gravitational** acceleration can be assumed to be constant at about 9.8 m/s^2.

A **hydraulic accumulator is a device** in which potential energy is stored in the form of a **compressed gas or spring**, or by a raised weight to be used to exert a force against a relatively incompressible fluid. They are used in fluid power systems to accumulate energy and to smooth out pulsations.

Liquid nitrogen is nitrogen in a liquid state at an extremely low temperature. It is produced industrially by fractional distillation of liquid air. Liquid nitrogen is a colourless clear liquid with density of 0.807 g/ml at its boiling point and a dielectric constant of 1.43. Liquid nitrogen is often referred to by the abbreviation, LN_2 or "LIN" or "LN" and has the UN number 1977. Liquid nitrogen is a diatomic liquid, which means that the diatomic character of the covalent N bonding in N_2 gas is retained after liquefaction

Pumped-storage hydroelectricity (PSH, or PHES) is a type of hydroelectric energy storage used by electric power systems for load balancing. The method stores energy in the form of gravitational potential energy of water, pumped from a lower elevation reservoir to a higher elevation, using the excess energy available from any other source.



Pumped Hydro-Electricity Energy Storage

A **capacitor** (historically known as a "**condenser**") is a device that stores energy in an electric field, by accumulating an internal imbalance of electric charge. It is made of two conductors separated by a dielectric (insulator). Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, an ideal **capacitor** does not dissipate energy. Instead, a **capacitor** stores energy in the form of an electrostatic field between its plates. The **energy stored** on a **capacitor** can be expressed in terms of the work done by the battery. Voltage represents **energy** per unit charge, so the work to move a charge element dq from the negative plate to the positive plate is equal to V dq, where V is the voltage on the **capacitor**.

Superconducting Magnetic Energy Storage (SMES) is a novel technology that stores electricity from the grid within the magnetic field of a coil comprised of superconducting wire with near-zero loss of energy. SMES is a grid-enabling device that stores and discharges large quantities of power almost instantaneously. The system is capable of releasing high levels of power within a fraction of a cycle to replace a sudden loss or dip in line power. Strategic injection of brief bursts of power can play a crucial role in maintaining grid reliability especially with today's increasingly congested power lines and the high penetration of renewable energy sources, such as wind and solar.

A **flow battery** is technically akin both to a fuel cell and an electrochemical accumulator cell (electrochemical reversibility). While it has technical advantages such as potentially separable liquid tanks and near unlimited longevity over most conventional rechargeables, current implementations are comparatively less powerful and require more sophisticated electronics. The energy capacity is a function of the electrolyte volume (amount of liquid electrolyte) and the power to the surface area of the electrodes. There is also variety of flow battery with Sodium and Sulphor in liquid form separated by a Solid electrolyte (power insulator) used by M/s. NGK Insulators of Japan, for wind farm operation.

A **rechargeable battery, storage battery, secondary cell, or accumulator** is a type of electrical battery which can be charged, discharged into a load, and recharged many times, while a non-rechargeable or primary battery is supplied fully charged, and discarded once discharged. It is composed of one or more electrochemical cells. The term "accumulator" is used as it accumulates and stores energy through a reversible electrochemical reaction. Rechargeable batteries are produced in many different shapes and sizes, ranging from button cells to megawatt systems connected to stabilize an electrical distribution network. Several different combinations of electrode materials and electrolytes are used, including lead–acid, nickel cadmium (NiCd), nickel metal hydride (NiMH), lithium ion (Li-ion), and lithium ion polymer (Li-ion polymer).

Ultra Battery is a hybrid energy storage device invented by Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO). Ultra Battery combines ultra-capacitor technology with lead-acid battery technology in a single cell with a common electrolyte.

A **fuel cell** is a device that converts the chemical energy from a fuel into electricity through a chemical reaction of positively charged

hydrogen ions with oxygen or another oxidizing agent. Fuel cells are different from batteries in that they require a continuous source of fuel and oxygen or air to sustain the chemical reaction, whereas in a battery the chemicals present in the battery react with each other to generate an electromotive force (emf). Fuel cells can produce electricity continuously for as long as these inputs are supplied. The advantage of fuel cell is that while it generates electricity by consuming oxygen and hydrogen also produces water as secondary output.

Glycogen is the main way the body stores glucose for later use. Since most of the carbohydrate we eat ends up as glucose, it's important to be able to store some of it to control blood glucose levels and provide glucose to the parts of the body that need it. Glycogen molecules are that storage. Glycogen in animals, including humans, has been compared to starch in plants, as starch molecules are the main glucose storage in plants.

Starch or amylum is a carbohydrate consisting of a large number of glucose units joined by glycosidic bonds. This polysaccharide is produced by most green plants as an energy store.

A **biofuel** is a fuel that is produced through contemporary biological processes, such as agriculture and anaerobic digestion, rather than a fuel produced by geological processes such as those involved in the formation of fossil fuels, such as coal and petroleum, from prehistoric biological matter.

A **hydrated salt** (or **hydrate**) is a **salt** which has a number of water molecules associated with the ions within its crystalline structure. These water molecules maybe referred to as the waters of crystallization or water of hydration.

Hydrogen is a chemical element with chemical symbol H and atomic number 1. With an atomic weight of 1.00794 u, hydrogen is the lightest element on the periodic table.

Power to gas (often abbreviated P2G) is a technology that converts electrical power to a gas fuel. There are currently three methods in use; all use electricity to split water into hydrogen and oxygen by means of electrolysis.

Vanadium (V) oxide is the inorganic compound with the formula V_2O_5. Commonly known as vanadium pent-oxide, it is a brown/yellow solid, although when freshly precipitated from aqueous solution, its colour is deep orange.

A **steam accumulator** is an insulated steel pressure tank containing hot water and steam under pressure. It is a type of energy storage device. It can be used to smooth out peaks and troughs in demand for steam. Steam accumulators may take on a significance for energy storage in solar thermal energy projects.

A **storage heater** or **heat bank** (Australia) is an electrical heater which stores thermal energy during the evening, or at night when base load electricity is available at lower cost, and releases the heat during the day as required.

Cryogenic energy storage (CES) is the use of low temperature (cryogenic) liquids such as liquid air or liquid nitrogen as energy storage. Both cryogens have been used to power cars. The inventor Peter Dearman initially developed a liquid air car, and then used the technology he developed for grid energy storage.

The **eutectic** reaction is defined as follows: This type of reaction is an invariant reaction, because it is in thermal equilibrium; another way to define this is the Gibbs free energy equals zero. Tangibly, this means the liquid and two solid solutions all coexist at the same time and are in chemical equilibrium.

Ice storage air conditioning is the process of using ice for thermal energy storage. This is practical because of water's large heat of fusion: one metric ton of water (one cubic metre) can store 334 megajoules (MJ) (317,000 BTU) of energy, equivalent to 93 kWh (26.4 ton-hours).

Molten salt is salt which is solid at standard temperature and pressure (STP) but enters the liquid phase due to elevated temperature. A salt that is normally liquid even at STP is usually called a room temperature ionic liquid, although technically molten salts are a class of ionic liquids.

A **phase-change material** (PCM) is a substance with a high heat of fusion which, melting and solidifying at a certain temperature, is capable of storing and releasing large amounts of energy.

Seasonal thermal energy storage (or **STES)** is the storage of heat or cold for periods of up to several months. The thermal energy can be collected whenever it is available and be used whenever needed, such as in the opposing season. For example, heat from solar collectors or waste heat from air conditioning equipment can be gathered in hot months for space heating use when needed, including during winter months. Waste heat from industrial process can similarly be stored and be used much later. Or the natural cold of winter air can be stored for summertime air conditioning. STES stores can serve district heating systems, as well as single buildings or complexes. Among seasonal storages used for heating, the design peak annual temperatures generally are in the range of 27 to 80°C (80.6 to 176.0°F), and the temperature difference occurring in the storage over the course of a year can be several tens of degrees. Some systems use a heat pump to help charge and discharge the storage during part or all of the cycle. For cooling applications, often only circulation pumps are used. A less common term for STES technologies is inter-seasonal thermal energy storage

A **solar pond** is simply a pool of saltwater which collects and stores solar thermal energy. The saltwater naturally forms a vertical salinity gradient also known as a "halocline", in which low-salinity water floats on top of high-salinity water and suck the heat through Heat Exchanger. The layers of salt solutions increase in concentration (and therefore density) with depth. Below a certain depth, the solution has a uniformly high salt concentration.

Thermal energy storage (TES) is a technology that stocks thermal energy by heating or cooling a storage medium so that the stored energy can be used at a later time for heating and cooling applications and power generation. TES systems are used particularly in buildings and industrial processes.

ENERGY STORAGE DEVICES

The following devices are using for storage of electrical energy, it depends upon size and volume of requirements [6].

1. Capacitor (Electro static)
2. Super Capacitor
3. Super Conductor (Magnetic)
4. Battery

5. Super Battery

Capacitor is an electronic component that stores electric charge. The capacitor is made of 2 close conductors (usually plates) that are separated by a dielectric material. The plates accumulate electric charge when connected to power source.

A **super-capacitor** (SC) (sometimes ultra-capacitor, formerly electric double-layer capacitor (EDLC)) is a high-capacity electrochemical capacitor with capacitance values much higher than other capacitors (but lower voltage limits) that bridge the gap between electrolytic capacitors and rechargeable batteries. They typically store 10 to 100 times more energy per unit volume or mass than electrolytic capacitors, can accept and deliver charge much faster than batteries, and tolerate many more charge and discharge cycles than rechargeable batteries. They are however 10 times larger than conventional batteries for a given charge.

Superconductors are materials that conduct electricity with no resistance. This means that, unlike the more familiar conductors such as copper or steel, a superconductor can carry a current indefinitely without losing any energy.

Batteries have three parts, an anode (-), a cathode (+), and the electrolyte. The cathode and anode (the positive and negative sides at either end of a traditional battery) are hooked up to an electrical circuit. The chemical reactions in the battery causes a build up of electrons at the anode.

Super Battery (M5BAT) : The world's first modular battery storage system with a performance class of five megawatts is being built in Aachen. This shall use lithium-ion batteries for, for example, short-term power storage, high-temperature batteries across several hours and lead-acid batteries for short and medium discharge times [7].

STORAGE APPLICATION

There are minimum 32 storage applications are referred with usage of methodology, which determined based on the following requirements for the energy storage system.

1. The type of feasible technology selection
2. Location clarified either supply or demand
3. The output energy types either thermal or electricity
4. The efficiency percentage
5. The initial and total cost of the investment viability
6. The primary application duration either long or short term confirmation

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Velachery - Tambaram Main Road, Pallikaranai, Chennai - 600 100.
Phone : +91-44-2246 3982, 2246 3983, 2246 3984 Fax : +91-44-2246 3980
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