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EDITORIAL

With wind industry facing a serious recession with first quarter registering an installed capacity of 264 MW, we need to think ways and means of harnessing the wind potential available in the Country in all the States. Wind Resource Assessment as declared by Government of India has an indicative potential of 103 GW at 80 m above ground level. The total installed capacity of wind power by the end of May 2013 is 19.3 GW which is less than 20 % of the indicated capacity. However, the dark days of power cut in the State of Tamil Nadu has been drastically reduced to a bare minimum with the energy generation from the wind touching 2000 to 3000 MW during this windy season which is about 20-30 % of the total energy generated and consumed in the State of Tamil Nadu. The exploitation of wind energy to the tune of 15 GW in Tamil Nadu at 80 m level needs large financial outlay in terms of development of transmission and distribution infrastructure from wind farm sites which are normally remote to the load centers of the Urban areas.

The wind generated electrical energy which is non-polluting green power is certainly linked to this evacuation infrastructure needed specially to make use the excess green electrical energy from higher monsoon winds with lower irrigation load. The National Clean Energy Fund generated from coal-cess is the right funding for evacuation, to promote the deployment of more green power such as wind and solar.

Several wind farm owners like C-WET are planning to make use of the free land available in wind farms to install solar power plant to pump electricity into the grid in the non windy seasons atleast during day time. With the provision of MW scale storage systems in substation with high RE penetration, any excess energy from renewable generations can be effectively used and contribute towards carbon emission reduction as well as implications of climate change in India.

A series of research projects taken up by R&D Unit of C-WET has certainly special emphasis on issues of power quality and grid interfacing of wind power are getting completed by the end of this year. The results of research projects which have manifestation of analytical simulation as well as field measurements would soon be made public.

The WRA Unit has been continuing their consultancies and the commissioning of 100 m towers for offshore wind profile measurement which is showing a steady progress. During the period several new wind monitoring stations including 100 m anemometry are in progress in several States. There was a Standing Parliament Committee at Gangtok, Sikkim to discuss the progress of resource assessment in such North Eastern States.

The Testing Unit has signed up two agreements during this season. Activities towards measurements are in progress. A project on wind forecasting through Indo-Spanish collaboration will be handled by the testing division along with the team of Scientists from other divisions of C-WET.

The S&C Unit of C-WET is continuing the renewal of Certificate to the old customers and periodical release of RLMM list is done after scrutiny of documents and the unit is also now vested with Proto-type facilitation duties by Ministry.

Due to the ever increasing IT infra structure in C-WET and energy management which requires uninterrupted power supply for 24 x 7 servers and for sustaining cyber security for all intranet/internet nodes in C-WET, a new division Engineering Service Division (ESD) has been launched with Senior Scientist, Shri Anvar Ali as the Unit Chief of the ESD Unit.

The ITCS Unit handled effectively the 10th International Training Programme and 14th National Training Programme on Wind Energy Technology. The Unit also actively participated in exhibition of "RENERGY-2013" at Chennai and explained Wind Energy activities of C-WET to several young visitors from Colleges and Schools.

The WTRS Unit has been maintaining the infrastructure to showcase to several VIP visitors from Government and the other student members.

The SRRA Unit is active in reformulating the Solar data policy of Ministry and also is pro-active in implementing phase II of SRRA monitoring stations at 60 locations covering the entire India and with 4 advanced monitoring stations which includes equipment for Aerosol measurements.

Scientists were also active in delivering invited lectures, publishing papers in International forums and participating in Ministerial delegation.

We would request the readers' blessings to continue our sustained effort to serve this Industry which needs much needed Government Policy support and enabling environment. Your feed backs would help us to serve you better.

S. Gomathinayagam
Executive Director

Contents

Editorial Board

Developments in R&D UNIT

Testing / Review of documents for Small Wind Turbine

Small wind turbine (SWT) testing at Wind Turbine Research Station (WTRS) for the windy season 2013 has started. Presently eight models of SWT's are under test with fresh agreement for testing two models underway. The models under test ranges from 1 kW to 10 kW. Final Test report for one model have been completed and handed over to the manufacturer.

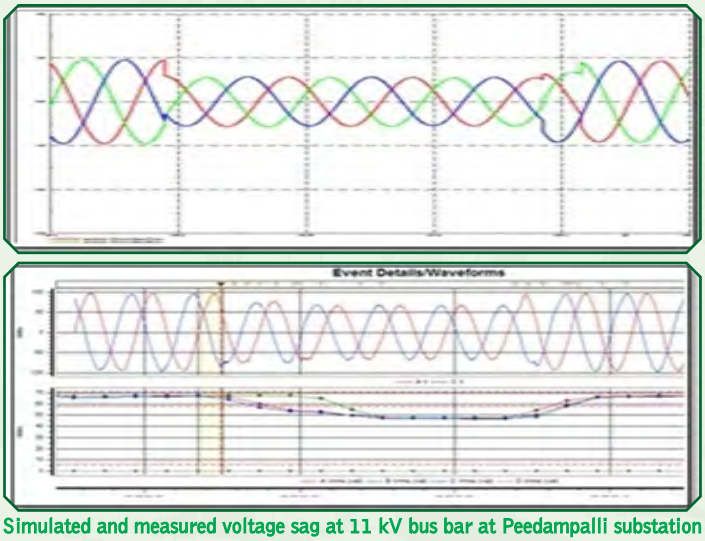
The 8th meeting of Small Wind turbine empanelment was held on 2nd April 2013 and the 8th Empanelment list has been published on the MNRE & C-WET websites for stakeholders reference.

Matrix converter based DFIG system

The Unit in association with SSN College of Engineering is working on study and control of weak grid connected matrix converter based 5 kW DFIG system. The simulation of the system has been completed. The matrix converter for the control of power flow in the DFIG has been developed. Presently, performance study of the DFIG unit interfaced with the power converter is in progress.

Study on Power Quality issues in grid connected wind farms and identification of remedial measures

As a part of this study, the Unit, in association with RMK Engineering College, has carried out modelling of squirrel cage induction generator for steady and dynamic state analysis of Peedamppalli wind farm. Simulations were carried out for the Peedamppalli substation to study the short circuit behavior, voltage variations, voltage sag, oscillatory transients and grid interruption. The simulations were validated with measurements at the substation.



Simulated and measured voltage sag at 11 kV bus bar at Peedampalli substation

Move on in WRA UNIT

During the period of April to June 2013, 7 new wind monitoring stations have been established in 3 States (2 station in Arunachal Pradesh, 3 stations in Orissa, 2 stations in Uttarakhand). Presently, 78 wind monitoring stations are operational in 17 States and 1 Union Territory 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 the reports submitted during this period

- Wind Power Density (WPD) map for 1 site.
- Technical Evaluation for the proposed 98 MW wind farm project.
- Feasibility Report on Site Assessment for 3 locations.
- Verification procedure of wind monitoring for 18 sites.
- Repowering of existing wind farm project at 1 location.

R&D projects in progress

- Installation & Commissioning of 100 m tall tower mast for offshore wind profile measurement is being carried out from 6th May 2013 onwards.
- Micro level wind atlas for Uttarakhand is under progress by using existing 5 km x 5 km mesoscale model data and the same will be submitted to NREL for preparing 1 km x 1 km resolution data.

- To study, analysis and validation of flow modeling tools by installing 5 nos. of 50 m mast in Complex Terrain is under process.
- Wind Resource Assessment in uncovered / new areas & complex terrains at 30 m level in the State of Tamil Nadu site selection has been carried out.

Other Programmes

- Ammonit software and data logger connection training has been carried out at C-WET, Chennai.

- Site survey for installing 120 m tall tower at WTTS, Kayathar has been carried out along with WTTS / C-WET and Tamil Nadu Electricity Board / TANGEDCO officials.
- Site visit was carried out at Assam from1st to 3rd May 2013 for M/s. NEEPCO by Mr. A. Haribhaskaran, Scientist.
- "Temples of Modern India" Wind Energy Video documentary had been suited at C-WET and WTTS / WTRS, Kayathar by M/s. Pulse Media Private Limited, New Delhi during 24th to 27th May 2013.

Steps forward in TESTING UNIT

- An agreement was signed between C-WET and M/s. Jyoti Limited for Type testing of WIND JYOTI – SE 850 – 56 / 70 kW wind turbine and measurements are expected to start during the windy season of 2013.
- An agreement was signed between C-WET and M/s. Xyron Technologies Limited for Type Testing of Xyron 1000 kW wind turbine on 14th May 2013 at Richadewda Ratlam District, Madhya Pradesh.
- An agreement was signed between C-WET and M/s. Inox Wind Limited for Type Testing of Inox 2000 kW wind turbine with rotor diameter 100 m on 14th May 2013 at Veraval (Bhadla) village (Survey No.8), Jastan Taluk, Rajkot District, Gujarat.

Agreement signed between C-WET and M/s. Inox Wind Limited

- Special Measurement Drive Train Analyis "Witnessing" at site for Garuda 700 kW WT at Melamaruthappa puram Village, Tirunleveli district has been carried out during 24th to 26th May 2013.
- An agreement was signed between C-WET and M/s. Garuda Vaayu Shakti Ltd. for Power Curve Measurements for Garuda 700 kW WT on 26th June 2013 at Melamaruthappapuram Village (SF No. 141/5) V.K. Pudur Taluk, Tirunelveli District.

Visitors to the Unit

- Mr. Vir Singh, Quality Assurance, M/s. Inox Wind Limited regarding agreement signed of their 2000 kW wind turbine held on 14th May, 2013.
- Mr. Aditya Bhatnagar, Director, M/s. Xyron Technologies Limited, regarding agreement signed of their 1000 kW wind turbine held on 14th May, 2013.
- Mr. Subhash M/s. Garuda Vaayu Shakthi Limited regarding discussion on Power Curve Measurements of Garuda 700 kW WT and their new request of Garuda 1.7 kW WT on 10th May 2013.

Marching ahead in S&C UNIT

Agreement has been signed with M/s. RRB Energy Limited for renewal of Certificate of V 39-500 kW with 47 m rotor diameter wind turbine model under Category-II as per TAPS-2000 (amended). Carried out review / verification of documentation in connection with renewal of Certificate of V 39-500 kW with 47 m rotor diameter wind turbine model. Based on the review / verification, renewed Certificate has been issued to M/s. RRB Energy Limited.

S&C Issuing renewed certificate to RRBEL

Review / verification of documentation / information obtained from various wind turbine manufacturers in connection with Revised List of Models and Manufacturers of wind turbines (RLMM) Addendum – II to Main List dated 31.07.2012 have been completed. Organized RLMM Committee meeting. RLMM Addendum – II list dated 13.05.2013 to Main List dated 31.07.2012, finalized by RLMM Committee has been issued.

C-WET has initiated the activities in connection with next RLMM Main List.

Review / verification of documentation received from various wind turbine manufacturers for installation of prototype wind turbine models in India as per MNRE guidelines is under progress.

Co-ordination works with Bureau of Indian Standards (BIS) and the members of the Working group on Standards in connection with standards related activities are ongoing.

S&C Unit has successfully undergone the recertification audit conducted by Det Norske Veritas (DNV) as per ISO 9001:2008 and the continual improvement and maintaining the Quality Management System are ongoing.

Visitor to the Unit

Mr. Rajni Umakanthan, Business Head - India & MEA, M/s. UL India Private Limited and Mr. Holger Soker, Technical Director & Head of Mechanical Loads, M/s. DEWI GmbH on 22nd April 2013.

Launch of ESD UNIT

In the modern resource assessment, Wind as well as Solar requires sophisticated instrumentation and data acquisition systems interfaced with net work server using GPRS mobile networks which need to be maintained 24x7 to facilitate resource data collection, storage, retrieval analysis and processing.

C-WETs infrastructure needs multi-disciplinary engineering services starting with Civil, Electrical, Information Technology and cyber security infrastructure, planning, maintenance and management. To cater to the above services, a new Engineering Service Division (ESD) has been established headed by a Senior Scientist Shri Anvar Ali. He is aptly assisted by Shri. Stephen Jeremias with flair for IT infrastructure management.

The 'ESD' Unit would also in the long run showcase the possible renewable energy mix in the day today energy consumption at C-WET and improve and demonstrate techniques of energy conservation as well as renewable energy penetration.

Management of IT infrastructures including networking of intra and internet facilities with focused attention on cyber security along with uninterrupted power supply to critical server ends computer system.

Activities on video conferencing and CCTV security system for C-WET have been initiated.

Highlights from ITCS UNIT

Tenth International Training Programme

ITCS Unit had successfully completed the Tenth International Training Programme on "Wind Turbine Technology and Applications" during 20th March – 12th April 2013, specially for African Countries sponsored by Ministry of External Affairs (MEA), Government of India and supported by Ministry of New and Renewable Energy (MNRE), Government of India.

The course was attended by 21 enthusiastic participants from 7 countries (Burundi, Cape Verde, Ethiopia, Libya, Nigeria, Tanzania and Uganda). The lectures were delivered by eminent scientists, engineers, wind turbine manufacturers, developers, utilities, consultants and academicians and other wind energy professionals with years and years of experience. During the 24 days of the course, 44 lecture were delivered of which 26 lectures were taken by 18 C-WET scientists & engineers and rest by 5 manufacturers, 4 developers, 2 consultants, and 4 premier Academicians, which included field visits to Wind Turbine Test / Research Station (WTTS / WTRS), Kayathar and wind farms in and around Kanyakumari.

Prof. J. S. Mani distributing the course certificate

National Training Course

The Unit had successfully organized the 14th National training course on “WIND ENERGY TECHNOLOGY” during 26th – 28th June 2013 with 44 participants having various educational and professional background attending the course coming from 11 States of the Country. The training course was inaugurated by Prof. Dr. Asit Baran Mandal,

Director, Central Leather Research Institute (CLRI), Chennai.

Prof. Dr. Asit Baran Mandal inaugurating the course

As part of every training course, a Course Material (compilation of the write-ups of all the presentations / lecturers submitted by the lecturers) specially prepared for that particular content of the course for the benefit of the participants.

Course participants in C-WET campus

Participation in Exhibitions

The Unit had established and managed C-WET stall in the RENERGY 2013, an International Renewable Energy Conference and Expo held at the Chennai Trade Centre, Chennai during 09th – 11th May 2013.

Visitors to the Campus

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 C-WET, schools and college students are encouraged to visit the campus. During the period from April – June 2013, the following visits were coordinated by ITCS Unit, with presentations and explanations by scientists on wind energy and it's status along with C-WET's activities & services during the visits and the campus renewable energy facilities were also explained / showcased in detail.

- 48 first year PG Students & 2 Staff Members of SRM University on 17th April 2013.
- 12 PG Students & 2 Staff Members of SKR Engineering College, Chennai on 17th April 2013.
- 50 M.Tech Students & 2 Staff Members of Power Electronics from VIT University, Vellore on 23rd April 2013.
- 18 PG Students & 2 Staff Members of ME Mechanical Engineering students of Adhiparashakthi College of Engineering on 13th May 2013.
- 82 Students & 4 Staff Members of RMK Senior Secondary School on 13th June 2013.

Windy Acts at WTRS UNIT

Preparation of 9 numbers 200 kW MICON Wind Electric Generators like conditioning of Transformers, Power Panels, Control Panels & brake calliper units completed for the windy season 2013.

Case study on reduction in gear oil temperature in one of the 200 kW MICON Wind Electric Generator by suitably replacing the gear oil cooler with fabricated improved version cooler, during the windy season 2013, under progress i.e., increasing the size of radiator fins from 330 mm x 262 mm x 65 mm to 400 mm x 332 mm x 65 mm.

Technical Visits

- Shri. R.P. Batra Director (Finance), MNRE, New Delhi visited the R&D / Testing facilities at WTRS, Kayathar on 16th March 2013.
- 28 Students and 2 Staff members from Amirtha School of Engineering, Coimbatore visited the R&D facilities at WTRS, Kayathar and exposure training imported to the students on safety measures on wind electric generators O&M / met masts measurements /

demonstration on small aero-generators testing etc on 28th March 2013.

- Delegates of 10th International Training Course on Wind Turbine Technology and Applications visited the Testing / R & D facilities at WTRS, Kayathar on 5th April 2013.

Advances in SRRA

- SRRA officials visited TEDA site for land survey in Kayathar and submitted Energy Estimation Report for Re-powering their site with the combination of Wind and Solar Energy.
- Purchase order for installation of 60 SRRA stations under Phase-II program was issued to M/s. SGS Weather & Environmental Systems Private Limited, New Delhi on 8th May 2013.
- Purchase order for installation of 4 Advanced Measurement Stations under Phase-II program was issued to M/s. SGS Weather & Environmental Systems Private Limited, New Delhi on 22nd May 2013.
- Micro-siting of Phase-II SRRA stations in Nagaland, Manipur, Tripura, Sikkim, Meghalaya, Mizoram, Jharkand, A&N Islands, Himachal Pradesh & Chandigarh were completed.
- Installation and configuration of Network attached storage (NAS) was completed to have multi location storage of QC processed SRRA data.
- Detailed Project proposal for Chennai Metro Rail was submitted to CMRL.
- Selling of SRRA data has been provided to many solar power developers.
- Site survey of Container Corporation of India (Concor), Thiruvottiyur for feasibility study for establishing solar system was carried out on 23rd May 2013 to assess the solar installable capacity in their campus.

New Infrastructure

- Calibration Laboratory has been established on the Terrace of the C-WET main building.

Visitors to the Unit

- Mr. Michael Williams and Mr. Krishnan S. Raghavan from United Nations ESCAP to learn about the solar energy as well as wind energy resource assessment mapping done at C-WET on 5th April 2013.
- Officials from ISE, VDE and PTP, Germany visited SRRA for discussions on strengthening Quality Infrastructure for solar industry in India.
- SEC and SECI officials for discussions on 9th May 2013.
- Mr. J. P Singh, Director MNRE, New Delhi for discussion regarding setting up of Calibration Lab in SEC, Gurgaon 9th May 2013.
- Mr. Bharath Kumar Reddy, SECI, New Delhi for discussions on 10th May 2013.
- Mr. Chalapathi Rao, Scientist-B, MNRE, New Delhi for discussions on 13th May 2013.

Awards & Appreciation

Shri P. Kanagavel, Scientist & Unit Chief i/c has been awarded for best design for IALA Journal published by Indian Academic Library Association (IALA), Tamil Nadu Chapter, Trichy on the occasion of Journal release in the workshop on "Library Information Skills Management" held at National College, Trichy on 21st May 2013.

Invited lecture delivered / meeting attended by C-WET Scientists in external forums

Dr. S. Gomathinayagam, Executive Director

- 2nd Offshore Wind Energy-Steering Committee Meet at New Delhi on 5th April 2013.
- Possibility of generating Electricity using Waves/Tidal Power, Offshore & Other renewable energy sources at IIT, Chennai conducted by BHEL on 6th April 2013.
- National Workshop with US Department of Energy on "Grid Integration of Renewable Energy Sources & Energy Efficiency" at New Delhi on 8th April 2013.
- Chief Guest at National Conference on Methods enriching power & Energy Development (MEPED'13) at Jeppiar College, Chennai on 12th April 2013.
- Chief Guest for Faculty Development Programme "Power Electronics for Green Energy" at Jerusalem Engineering College, Chennai on 15th April 2013.
- International Renewable Energy Agency (IRENA) Meet at New Delhi on 16th April 2013.
- Research & Development meet on Small Wind Turbine at C-WET on 22nd April 2013.
- Workshop on Offshore Wind Power Development in India by ITP at New Delhi on 25th April 2013.
- Doctoral Committee Meeting at MIT, Anna University, Chennai on 26th April 2013.
- Kick start meeting for implementation of R&D project for "Setting up facility for Calibration of Solar Radiation Measuring sensors and its Analysis/modeling based on

ground surface measurements" at New Delhi on 30th April 2013.

- Wind Independent Power Producers Association (WIPPA) at Chennai on 10th May 2013.
- Chief Guest & Keynote Speaker in the Industry Institute Interaction Conclave (IIIC 2013) at Sri Ramakrishna College of Engineering, Coimbatore on 30th May 2013.
- Review Meeting on Project for Assessment of Wind Power Potential at 100 m level in 7 wind potential States at New Delhi on 6th June 2013.
- Parliamentary Standing Committee on Energy at Gangtok and Darjeeling during 7th to 11th June 2013.
- Task Force Meeting of CPRI on R&D under NPP on Distribution and Distributional Generation at Bangalore on 14th June 2013.
- NCEF IMG- Meeting on proposed 500 Nos. of wind monitoring stations at 100 m level in covered/new areas in India at New Delhi on 18th June 2013.

K. Boopathi

- Low Emissions Asian Development (LEAD) programme sponsored by United States Agency for International Development (USAID) and the United States Department of Energy's National Renewable Energy Laboratory (NREL) and implemented by ICF International held at Bangkok, Thailand during 4th - 5th April 2013.
- 4th Clean Energy Ministerial and Wind Solar Technology Meeting at New Delhi on 16th April 2013.
- "Wind Resource Assessment" in the AICTE - FDP on "Renewable Energy" organized during 13th to 23rd May 2013 by the Department of Mechanical Engineering of Pondicherry Engineering College, Pondicherry on 16th May 2013.
- "Recent trends in WRA and technology" at VIT, Kelambakkam Chennai on 4th May 2013.
- Technical Evaluation Committee Meeting for Development of Wind Power programme in Kerala at Trivandrum, Kerala for M/s. ANERT on 22nd May 2013.
- Meeting with Rameswaram Tasildar & VAO for Inspection of Civil Foundation Work for Installation & Commissioning of 100 m tall mast at Dhanushkodi on 6th May 2013 along with Shri. Suresh Kumar, Junior Engineer, WRA.
- SNA Meeting at MNRE, New Delhi on 6th June 2013 along with Shri A. Haribhaskaran, Scientist, WRA.
- Parliamentary Standing Committee on Energy at Gangtok and Darjeeling during 7th to 11th June 2013.

S.A. Mathew

- "Wind Resource Land Mapping using ArcGIS, WAsP and Multi Criteria Decision Analysis (MCDA)" in the 2013 International Conference on Alternate Energy in Developing Countries and Emerging Countries - 2013 AEDCEE at Bangkok, Thailand during 30th - 31st May 2013.

A. Mohammed Hussain

- Member at the 11th Governing Body meeting of Agency for Non-Conventional Energy and Rural Technology (ANERT), Trivandrum, Kerala State on 22nd May 2013.
- Expert panel member during the panel discussion at the one day Workshop on "Energy & Environment" conducted by Kerala State Industrial Development Council (KSIDC), Trivandrum on 14th June 2013.

A. Senthil Kumar

- "Wind Potential in Tamil Nadu" in the workshop on Wind Energy in TN-Challenges and Constraints faced in tapping wind potential and its impact in the State Power situation and its improvements organized by Tamil Nadu State Planning Commission in collaboration with Panchabuta – Renewable Energy and Cleantec.

P. Kanagavel

- "Wind Energy: An Comprehensive overview" in the AICTE - FDP on "Renewable Energy" organized during 13th to 23rd May 2013 by the Department of Mechanical Engineering of Pondicherry Engineering College, Pondicherry on 16th May 2013.
- "Wind Energy Technology & Applications" in the Faculty Development Programme (FDP) on "Recent Trends on Conventional & Renewable Energy Sources and Technology" organized by VSVN Polytechnic College, Virudhunagar on 23rd May 2013.

R. Sasikumar

- Multi Lateral Solar and Wind working group organized by IRENA and CEM, India Habit at Centre, New Delhi on 16th April 2013.
- A Technical Evaluation Committee Meeting of SRRA for clarification of bids received was held at C-WET on 3rd April 2013.

Visits Abroad

Dr. S. Gomathinayagam, Executive Director, C-WET accompanied Hon'ble Minister Dr. Farooq Abdullah, MNRE for official delegation to Turkey on Renewable Energy Cooperation from 25th to 27th June 2013.

S.A. Mathew, Scientist & Unit Chief, WTT invited as a nominee and participated in the 2013 International Conference on Alternate Energy in Developing Countries and Emerging Countries – 2013 AEDCEE at Bangkok, Thailand during 30th – 31st May, 2013.

Dr. G. Giridhar, Scientist & Unit Chief, SRRA attended the "Course 1 on Energy Essentials for Decision Makers" in the Energy Training Week organized by International Energy Agency (IEA) during 6th -13th April 2013 at Paris.

S. Arulselvan, Assistant Engineer, S&C attended the "Wind Power Development and Use" as part of International Training Programme organized by LIFE Academy Sweden and sponsored by SIDA, Sweden during 8th to 24th April 2013.

The following staff delivered lecture(s) in the 10th International Training Programme on "Wind Turbine Technology and Applications" held during 20th March – 12th April 2013

No	Title	Speakers
1	✦ Type Certification of wind turbine and overview of Design Requirements as per IEC 61400 - 1	**Shri. A. Senthilkumar,** Scientist & Unit Chief, S&C
2	✦ Design requirements of Control and Protection System	**Shri. S. Arulselvan,** Assistant Engineer, S&C
3 4	✦ Wind Turbine Testing & Measurement Techniques ✦ Power Curve Measurements	**Shri. S. A. Mathew,** Scientist & Unit Chief, WTT
5	✦ Instrumentation for Wind Turbine Testing	**Shri. M. Saravanan,** Scientist, WTT
6	✦ Safety and Function Testing	**Shri. M. Anvar Ali,** Scientist & Unit Chief, ESD
7	✦ Small Wind Turbine Testing and Hybrid Systems	**Shri. Rajesh Katyal,** Scientist & Unit Chief, R&D
8	✦ Solar Energy and Solar Radiation Resource Assessment	**Shri. Prasun Kumar Das,** Scientist, SRRA
9	✦ Environmental Aspects of Wind Turbine Technology	**Shri. P. Kanagavel,** Scientist & Unit Chief i/c, ITCS
10	✦ Indian Government Policies, Schemes and Legal Frameworks	**Shri. Mohammed Hussain,** Scientist & Unit Chief, WTRS

As the course scheduled during March & April 2013, lectures taken during March published in the previous issue of PAVAN.

The following staff delivered lecture(s) in the 14th National Training course on "Wind Energy Technology" held during 26th – 28th June 2013

No	Title	Speakers
1	✦ Wind Energy Conversion Technology and Power Generation: Introduction (Notes : Dr. S. Gomathinayagam) ✦ Role of C-WET in Wind Energy Development	**P. Kanagavel** Scientist & Unit Chief i/c, ITCS
2	✦ Wind Resources Assessment & Techniques ✦ Wind Turbine Components	**K. Boopathi** Scientist & Unit Chief i/c, WRA
3	✦ Wind Electric Generators and Types & Grid Integration of Wind Turbines (Notes : Deepa Kurup)	**Shri M Anvar Ali,** Scientist & Unit Chief, ESD
4	✦ Control and Safety System of Wind Turbine Systems	**Shri. S. Arulselvan,** Assistant Engineer, S&C
5	✦ Indian Government Policies	**Shri. Mohammed Hussain,** Scientist & Unit Chief, WTRS
6	✦ Wind Turbine Testing	**Shri. S. A. Mathew,** Scientist & Unit Chief, WTT
7	✦ Wind Turbine Tower and Foundation Concepts ✦ Small Wind Turbines and Hybrid Systems	**Shri. Rajesh Katyal,** Scientist & Unit Chief, R&D
8	✦ Solar Energy and Solar Radiation Resource Assessment	**Dr. G. Giridhar,** Scientist & Unit Chief, SRRA
9	✦ Type Certification of wind turbine	**Shri. A. Senthil Kumar,** Scientist & Unit Chief, S&C

15th National Training Course of C-WET in 2013 Lookout! (Please visit cwet.res.in) 27th to 29th November 2013

POWER SYSTEM STUDIES FOR RENEWABLE INTEGRATION

Ms. Rashmi Sekar, Manager & **Dr. K. Balaraman,** Chief General Manager, E-mail : balaraman@prdcinfotech.com
Power Research & Development Consultants Private Limited, Bangalore

Abstract

In recent years, renewable energy (RE) has become an important part of electrical generation in many countries and its importance is continuing to increase. The amount of renewable generation in particular wind, is growing rapidly and their capacities are growing in size and complexity. Wind & solar farms are being installed consisting of hundreds of individual WTG's (or solar modules), which are capable of producing hundreds of MW. The location of a Renewable generation (both solar and wind) is selected primarily based on favorable land scape and environmental conditions. However it is generally observed that the good regions often coincide with relatively remote parts of the power system as there is a need for land footprint. Thus the operation of the Renewable energy generation and its response to disturbances or other changing conditions on the power system is becoming of increasing concern, especially in cases where the renewable energy represent a significant portion of the local generation. These concerns will continue to grow in importance as the amount of Renewable generation increases.

In order to integrate large amounts of RE power plants successfully, a number of issues need to be addressed, including design and operation of the power system, grid infrastructure issues and grid connection of RE power. In order to investigate the effects of the RE on the grid, it is necessary to carryout detailed simulation studies ranging from steady state to dynamic conditions. The simulations are carried out for various times frames and various operating conditions so as to ensure that power system would be operated in secure state under all the operating conditions.

Introduction

The planning, design and operation of commercial and industrial power system requires a continual and comprehensive analysis to evaluate current system performance and to establish the effectiveness of the alternative plans for operating the system. The computational work to determine power flows and voltage levels resulting from single operating condition for even a small network is all but insurmountable if performed by manual methods. The need for computational aids led to the design of a special purpose analog computer (ac network analyzer) as early as 1929. It provided the ability to determine flows and voltages during normal and emergency conditions and to study the transient behavior of the system resulting from fault conditions and switching operations. The earliest application of digital computers to power system problems dates back to the late 1940s. Most of the early applications were limited in scope because of the small capacity of the punched card calculators in use during that period. Large-scale digital computers became available in the mid-1950s, and the initial success of load flow programs led to the development of programs for short-circuit and stability calculations. Today, the digital computer is an indispensable tool in power system planning, in which it is necessary to predict future growth and simulate day-to-day operations over periods of twenty years or more.

The power system simulation is carried out for different time frames for different purpose. For renewable energy integration, different time scales would mean different models and the data for their impact studies. The description of various impacts is shown in Fig.1.

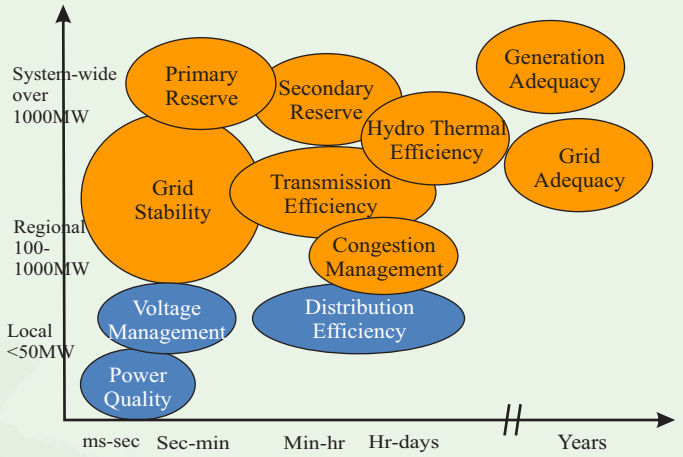


Fig. 1. Impacts of wind power on power systems, divided in different time scales and width of area relevant for the studies in this international collaboration (IEA WIND Task 25)

In order to understand the impacts, various analysis tools are considered. In general, the power system analysis is grouped into two categories, viz., steady state analysis and dynamic analysis. In steady state analysis, it is assumed that any transients from the disturbances are settled down and the system state remains unaltered i.e., the system load including transmission system losses are matched with power generation. The primary tools for analysis for steady state operation is so called power flow analysis or load flow studies where the voltage and power flow through the system is determined. Another very popular steady state analysis tool is the short circuit analysis for determining the fault current through system.

Power System Studies

The power system studies carried out for Renewable Energy generation are;

a. Load Flow studies: This is the most common study to be carried out for designing the basic network for connectivity between the generators or module and also for evacuation of power. The study would also be used for optimization for the unit commitment process and evaluate the power quality aspects.

b. Short circuit studies: This study is useful in understanding the fault level in the system so as to design the equipments and also for protection co-ordination.

c. Stability studies: Stability studies are needed whenever the contribution (penetration) from RE sources in a utility system exceeds 10% of the demand so as to understand the interaction between the RE generators and conventional power plants. The studies are used for designing dynamic compensation system whenever the power quality is threatened and to ensure reliability of the system.

d. Wind turbine starting studies: In a large wind farm, if all the wind turbines are started together, the current drawn from the grid would be high which may result in voltage dip. Hence, there is a limitation in starting the number of machines at the same time. This can be obtained through this study and would be dependent on the fault level of the system.

e. Harmonic analysis: The power electronic circuit connected to the power system would result in generation of Harmonics. Hence there is a need to design appropriate filters in reducing these harmonics.

In additional to above, there are special studies like overvoltage studies and switching transient studies which may be required depending on the geographical location and also local system conditions.

Power system problem formulation

The goal of a power flow study is to obtain complete voltage angle and magnitude information for each Bus in a power system for specified load and generator real power and voltage conditions. Once this information is known, real and reactive power flow on each branch as well as generator reactive power output can be analytically determined. Due to the nonlinear nature of this problem, numerical methods are employed to obtain a solution that is within an acceptable tolerance.

The solution to the power flow problem begins with identifying the known and unknown variables in the system. The known and unknown variables are dependent on the type of Bus. A bus without any generators connected to it is called a Load Bus. With one exception, a Bus with at least one generator connected to it is called a Generator Bus. The exception is one arbitrarily-selected bus that has a generator with high generator connected and would be referred to as the Slack Bus.

In the power flow problem, the real power P and reactive power Q at each Load Bus are specified and hence they would also be called as PQ Buses. For Generator Buses, the real power generated PG and the voltage magnitude |V| is specified (hence also called as PV Buses). For the Slack Bus, the voltage magnitude |V| and voltage phase Θ (phase angle is assumed to zero or any other reference) are specified. Therefore, for each Load Bus, the voltage magnitude and angle are unknown and must be solved for; for each Generator Bus, the voltage angle and reactive power generation must be solved for.

Modeling of Renewable Energy Generation for Power System Studies

The objective of a load flow analysis is to determine flows on transmission lines and transformers along with voltages. This calculation is essential in the planning and design of the interconnection of the RE sources to the power system to ensure that existing equipment is operated within its capabilities and new equipment is properly sized. Such calculations are performed under base case (normal conditions, all equipment generally in service) and contingency conditions (one or more power system elements such as lines, generating units or transformers out of service). System performance is compared to operating limits and criteria. These computations are often performed for different system conditions such as peak load, light load, different seasons or different power transfer conditions. From the standpoint of the wind farm & solar farms, these studies are primarily to determine if the generated power can be evacuated to the load centers or purchasing entity without any constraints such as overloading or voltage problems. The modeling of the ability (or lack of ability) of the wind farm to control voltage through control of the reactive power output of the units is very important as well.

The model of the RE (wind or solar) farm can be considered to have two potential levels of representation:

- A detailed model of the RE farm, representing individual units and the connections between these units and the system. A large RE farm may have over a hundred units. These units are generally spread over a large area, typically connected by a series of feeders. These feeders are typically connected at a “collector” Bus which is connected to the power system. The detailed model would thus consist of, say, a hundred or more Buses and a similar number of lines. Very detailed data on the system connecting the wind turbine / RE generators would need to be supplied by the developer. These detailed models can be used to determine voltages and flows within the RE farm, as well as the injection into the utility grid. The model can be used to check / design voltage control or reactive power strategies in the RE (wind or solar) farm along with incidental power system losses in the farm.
- The RE farm can be modeled as equivalent injection from the power system point of view for grid integration studies. Here, the concern is not on the individual units

but on the aggregate effect of the entire farm on the power system. The individual generators are lumped into equivalent machines, generally represented at the collector Buses. Thus, the size of the system representation of the RE farm is reduced to a few Buses and the data requirements are significantly reduced. This level of modeling is often used in system studies where the effects of the injection into the system on system flows and voltages are the concern, and internal RE farm conditions are neglected.

Therefore, for the large scale RE studies, detailed model in which there is a need to represent many generators and thus a significant amount of data must be entered may not be required and thus lumped representation in which an equivalent of the RE farm would suffice for the evacuation studies.

Grid Integration Issues with RE sources

The key issues for integrating large capacity of RE sources into the grid are on the planning, operation and transmission upgrades. These issues were less & insignificant when their penetration level is low. But, with high RE penetration, grid behavior would change significantly with changes in these intermittent generation as the characteristics of RE generators are quite different from the conventional power plants. The major issues of RE integration can be addressed by;

- The changed approaches in operation of the power system,
- Connection requirements for RE power plants to maintain a stable and reliable supply,
- Extension and modification of the grid infrastructure and
- Understanding influence of RE power on system adequacy and the security of supply.

The key factors to be considered in the power system studies are

Load generation balance analysis / evacuation study scenarios

- Power evacuation studies for conventional power plants, are generally conducted as stipulated in "Transmission Planning Criteria" for annual system peak load and light load conditions for maximum Hydro / Thermal generation scenarios. Evacuation studies would be analyzed for various scenarios to examine the ability of the different elements of network to carry the power during peak hours without network congestion and voltage violations including under contingency conditions stipulated in the relevant grid codes. System studies also examine whether voltage excursions are within limits particularly during light load hours and help to suggest measures to keep the voltages within acceptable limits.
- However renewable energy projects like wind & solar are generally located in remote locations from load centers and may require long transmission lines to major load centers. The local sub-station loads near these plants during peak generation are another important factor to be considered. If the local substation loads are low, then the entire generation may have to be transported to the nearest major grid substation for further absorption in the grid and this ability of the network has to be checked in the evacuation studies to avoid backing down of generation. In general, annual system peak loads generally occur in summer months (may be due to high agriculture, cooling loads in residential / industrial / commercial loads) and however, when wind speeds are high, this will bring the cooling effect in the area and hence system loads would be less. Hence, for wind power evacuation studies, the system peak loads during peak wind generation period would be in the order of 70% to 80% of the system annual peak load (as seen in some of the states in India). The corresponding minimum load during peak wind season that may occur in night hours when wind generations hit the peak is another important scenario that has to be analyzed. The network data collection therefore has to include the wind generation pattern month on month and local substation loads for the corresponding periods so as to carry out wind power integration studies for these critical scenarios.
- In case of solar generation, the demand in the vicinity may be high and the corresponding loads may have to be considered. The most important aspect incase of solar generation is that the ambient temperature would be high which would limit the loading of transmission lines and transformers.

Table 1: Critical scenarios to be analyzed for RE power evacuation

Sl. No.	Wind generation	Solar Generation	System demand	Local demand	Local Conventional
1	Maximum	Maximum	Maximum system demand during peak RE season	corresponding local load	Maximum
2	Maximum	Minimum	Minimum system demand during peak RE season	corresponding local load	corresponding conventional generation
3	Maximum	Maximum	Maximum system demand during peak RE season	local S/S light load in peak wind generation	Maximum
4	Maximum	Minimum	Minimum system demand during peak RE season	local S/S light load in peak wind generation	corresponding conventional generation
5	Minimum	Maximum	Maximum system demand during off-peak RE season	corresponding local load	Maximum
6	Minimum	Minimum	Minimum system demand during off-peak RE season	corresponding local load	corresponding conventional generation

- Thus, load flow studies for peak wind integration have to be simulated for minimum and maximum system demand during peak wind season, respective other renewable generation dispatch (solar / hydro in peak wind season) and maximum conventional generation dispatch particularly in wind farm area in order to;

- develop a reliable wind power evacuation system
- examine the impact of simultaneous injection of all renewable generation (solar, wind & hydro) on the network and whether any network congestion occurs or not

- Load flow studies for off-peak wind generation season also has to be simulated for minimum system demand and maximum system along with respective other renewable generation dispatch (solar / hydro in off-peak wind season) and maximum conventional generation dispatch particularly in wind farm area to examine whether the bus-voltages are within limits and help to suggest measures to keep the voltages within acceptable limits
- Load Flow studies for Solar integration may have to be simulated with day peak conditions as the generation would be higher during mid-day.

Wind farm capacity factors for grid integration studies

- The ratio of maximum generation in MW to the sum of installed capacity of individual WTGs in the wind farm. Normally in India, plant load factors of wind farms would lie in the range of 20-30%. But capacity factor may go up to 100% in small wind farm. So to have economic viability, transmission planning of wind farms should consider capacity factor as a parameter. Large wind farm is a collection of wind generators geographically wide spread considering the spacing factors based on technical factors. It is to be noted that all wind generators in a large wind farm may not generate full capacity (equal to the installed capacity) simultaneously at any point of time as wind speeds may not be uniform over the entire wind farm spreading over several tens of hectares.
- Based on consultants experience in analysis, the capacity factor shall correspond to following during high wind season;
  - 100% for small wind farms (less than 40 MW and connected at 33 kV and at 66 kV level)
  - 90% for medium wind farms (between 40-100 MW and connected to grid at 66 & 110/132 kV networks)
  - 85% for large wind farms (between 100 MW-200 MW & connected to grid at 132 kV, 220 kV)
  - 80% for very large wind farms (>200 MW & connected to grid at 220 kV & above) while carrying out the power evacuation studies. For small wind farms connected at 33 kV & below, the capacity factor can be unity.

Transmission line loadability

- The loadability of transmission lines depends not only on the size & material of the conductor used, but also on the area ambient temperature and the transmission line design standards followed by the area transmission up utility like allowable maximum conductor temperature (65 or 75 or 90° c) / permitted sag / wind speed, etc.
- Generally transmission line ampacity calculations are calculated as per IEEE calculations considering wind velocities of 0.5 m/sec and experience has shown that minimum cut-in speed for wind turbines are > 3 to 3.5 m/sec. Considering 1 m/sec or 1.5 m/sec wind speed (duly factoring that transmission lines are at much lower height as compared to wind turbines & transmission lines run several 10's of km from Wind Farm site where wind velocities may not be same), an increased ampacity of 20 - 30 % is possible in peak wind season. This can be considered safely while deciding loading of transmission lines particularly in contingency conditions which are not frequent to avoid additional investments for enhancing evacuation reliability. However, due attention need to be paid-for in controlling reactive power requirement with additional compensation.
- In case of solar power plants, the ampacity of the lines and transformer would be lower due to higher ambient temperature which needs to be considered specific to the location before permitting the loading.

Conclusions

Renewable energy sources of electricity has two wonderful attributes namely, no air pollutants and extremely low operating costs. It is in the interest of the country to harness this potential by integrating these energy into the grid. The solution to all the outstanding issues and other issues which may crop up later can be found to harness this nature's gift through series of analysis. In this regard, power system analysis play a great role in understanding and resolving the issues.

The capacity of power systems to absorb large scale RE generation is determined more by economics and regulatory rules than by technical or practical constraints. With increase in penetration, a common approach need to be taken for incorporating RE generation by transmission planner, system operators and developers by adopting grid codes specific to wind generators.

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