pavan

C-WET
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A News Bulletin from CENTRE FOR WIND ENERGY TECHNOLOGY, Chennai

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EDITORIAL

Nearing 15 GW installed capacity in India the wind power growth is considerably sustained as well as steady. It is not without any serious issues since the wind infirmity needs to be addressed by the distribution companies (DISCOM) of various states in India. One of the states which is immensely affected by the excessive penetration of wind to the extent of 55% of base power generation capacity from various sources is Tamil Nadu. Tamil Nadu is having almost the tune of 20% of its total electrical energy generation from wind during the windy months, which just got over. This is one of the highest penetrations of wind energy in the Grid comparable to Denmark a leading country which has over 21% energy mix from wind.

The several lessons needed to be learnt to overcome the hurdles of weak grid as it is in India and power predictability of wind as well as wind power. This is possible by consorted and focused efforts on renewable energy policy in high penetration region involving various sources of distributed energy generation and usage, which is need of the hour.

Today most of the urban population can afford to have an inverter to tide over the innumerable power cuts both scheduled and un-scheduled with less than 10% of the cost of their apartment / flat. A roof top wind – solar hybrid system can charge the inverters as well as power the grid if net-metering policy is enabled. This is not a myth since in a family where both partners are going for job it is possible to export the energy generation from wind and solar in to the grid, for which technologies are proven and are existing. There needs to be an attitudinal change and enabling policy measure to make this happen, which will provide power to many people who are currently deprived.

With this positive note on wind energy development in the country, C-WET has been actively involved through its multi institutional partnership for studies on power evacuation and power quality issues in grid connected wind farms. The results of the project will be an eye opener in the future planning.

Wind Resources Assessment has been quite active with several consultancy projects on data verification, due diligence and wind resources assessment. The unit has recently acquired vertical as well as horizontal wind profiler using the Light Detection And Ranging (LIDAR) techniques. The unit is constantly following up to measure wind resource between Sri Lanka and India to make a quantitative assessment of Indian off-shore wind potential in the local region.

The Testing Unit is busy with three wind turbine testing in the southern district of Tamil Nadu. The unit is also planning for Inter Laboratory Comparison (ILC) with NREL, USA. The proposals on 'Blade Testing Centre (BTC) facilities for India and move towards the "Centre for Excellency (CEOE)" in wind energy measurements have been in plan.

The Standards and Certification unit has been flooded with applications for inclusion in RLMM list with revised policy of self-certification booming the Indian market with as many as 45 models from 23 manufacturers. The unit is also quite active in the formulation of the Indian standard for wind turbines with Bureau of Indian Standards (BIS).

Information, Training and Commercial Services unit has successfully completed 7th International training programme under ITEC/MEA umbrella as well as hosted number of students and other distinguished visitors in the campus.

Solar Radiation Resource Assessment unit under the mission mode has completed as many as 40 out of the planned 51 Automatic Solar Radiation Monitoring Stations (ASRMS). The unit has made available daily averages of monthly data from the already commissioned stations in the C-WET and MNRE website for public information.

The newly formed Hybrid Wind System unit is slowly getting established with only one active scientist as of now. Invited lectures and course lectures and couple of publications marked the series of activities during this period. Apart from planning of 12th Five Year Plan on wind energy sub-group meetings and policy formulations assistance of MNRE, C-WET is ready to re-dedicate itself for wind energy research.

We request your valuable critical and constructive comments on PAVAN which is only a record of C-WET's activities online view for our continuous improved services to the wind energy industry in India and abroad.

S. Gomathinayagam
Executive Director

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Developments in R&D UNIT

Power Evacuation Studies for Grid Integrated Wind Energy Conversion System

The power evacuation study for Grid Integrated Wind Energy Conversion system is one of the major issues faced by both Wind Turbine Industry and Utility, particularly in the state of Tamil Nadu. The R&D unit had initiated a project of one power evacuation study for identifying weak point in the power system, conducting load flow analysis & short circuit analysis by modelling the Wind Turbine, TCSC & VSC based HVDC lines and conducting power evacuation studies to develop stability model and transient stability analysis for Wind Turbines. The project aims to identify the locations where wind penetration to the grid is a problem and enhance the power evacuation with a TCSC (Thyristor Controller Series Capacitor) controller and VSC (Voltage Source Convertor) based HVDC (High Voltage Direct Current Transmission) link. The work is underway and is likely to be completed by August 2012.

R&D Agreement between C-WET and SSN College of Engineering, to develop and test a Matrix converter applied to DFIG based Wind Energy Systems

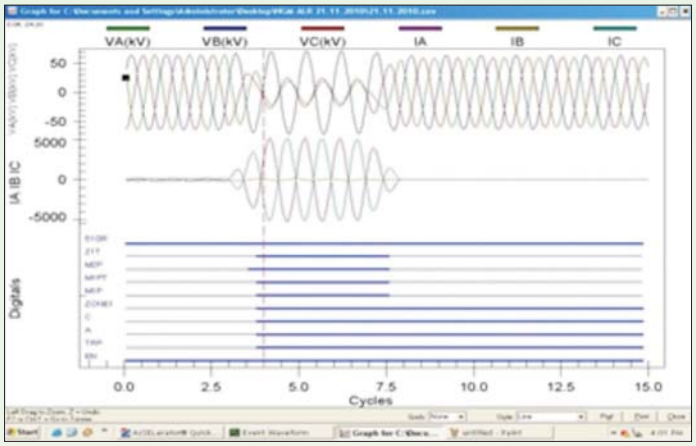
The R&D unit has initiated a project with the help of SSN College of Engineering, Chennai approved by the Research Council of C-WET to undertake simulation of the Matrix Converter controlled Doubly Fed Induction Generator (DFIG) system and development of needed hardware modules and is likely to be completed by 2014.

Signing of MoU with SSN College of Engineering

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

The power quality is also one of the major areas of interest, particularly in weak grid scenario. For this purpose, R&D unit has initiated a project jointly with Tamil Nadu Energy Development Agency (TEDA), RMK Engineering College and Amrita School of Engineering to undertake the power quality issues in the grid, connected wind farms and to recommend appropriate integration of the new wind generation system foreseen for the Indian wind power based on measurements at site and simulation studies.

Power quality data has been collected from the Coimbatore circle, which are exclusively connected with wind turbines and the data is being used for the simulation work.



Voltage parameter monitored at Wind Farm in Coimbatore circle

Move on in WRA UNIT

During the period of July to September 2011, 17 new wind monitoring stations have been established, 11 stations in Andhra Pradesh, 6 stations in Ladakh (Jammu & Kashmir). Presently, 95 wind-monitoring stations are operational in 20 states and one union territory under various wind monitoring projects funded by the Ministry of New and Renewable energy as well as various entrepreneurs.

Projects on Verification of procedure of wind monitoring have been done for the following sites.

1) Adwadi, Tulsan, Mokkal Diggi, Mahiderchotila, Bheseda, Dangiri, Ramgad, Habur, HPCL-1, Suro Ki Dhani – North, Suro Ki Dhani –West, Kubhariya, Soda Bandhanand Tejuva west for M/s. Suzlon Infrastructure Services Ltd, Pune.

2) Navelewadi for Shubh Wind Power Private Limited, Davanagere.

3) Eguvapalli for Guttaseema Wind Energy Company Private Limited, Hyderabad.

4) Ramasagaram for M/s. Gamesa wind Turbines Private Limited., Chennai.

5) 57 sites in Maharashtra for M/s. Maharashtra Energy Development Agency, Pune.

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

- Site Validation & Generation Estimation of proposed wind farm project at Jamb Amberi, Satara District, Maharashtra for M/s. Kenersys India Private Limited, Pune.

- Load flow analysis for integration of 3 x 250 kW wind turbines with D. G. sets at Kavarathi, Lakshadweep for M/s. Power Research Development Consultants Private Limited, Bangalore.

- Variation of Surface Winds at Chakla, Jaibhim and Mogarpada sites in Maharashtra for M/s. Suzlon Energy Limited, Pune.

- Site assessment for wind monitoring in Andhra Pradesh for M/s. Ecoren Energy India Private Limited, Hyderabad.

A Training Program for Mi-Power software has been organised for WRA staff by Power Research & Development Consultation Pvt. Ltd. (PRDC), Bangalore during 11th - 15th July 2011 at their campus.

To obtain the orientation about LIDAR facilities and operation, a three days training programme was organised at WTRS/WTTS, Kayathar during 23rd - 25th August 2011.

Wind profiling by using LIDAR

LIDAR is an acronym of Light Detection And Ranging (LIDAR). It is a technique to measure the distance between the sensor, a laser source of light and an object. By precisely timing of the round trip return time of a pulse of light backscattered from the target, its location can be calculated. LIDAR uses ultraviolet, visible or near infrared light to image objects. Wavelengths in a rage from about 10 micrometers to the UV (ca. 250 nm) are used to suit the target. Typically light is reflected via backscattering. There are two types of LIDAR techniques are available.

1) Pulsed LIDAR, 2) Continuous Wave LIDAR

WRA unit has procured a Continuous Wave LIDAR for measuring wake behind the wind turbine as well as measuring horizontal wind speed. The LIDAR consisted of a rack unit containing a laser source, detector and signal processing computer. The LIDAR emits a continuous un-modulated radiation beam. The detector output is then processed in discrete chunks at a rate determined by the signal processing and other system requirements. Such system achieves operation at different ranges by focusing at each chosen range in turn. Ten different sensing heights can be chosen. Each height is scanned for 3 seconds before the LIDAR re-focuses to the next height in the sequence. The laser light is emitted through a constantly rotating prism giving a deflection of 30 degrees from the vertical and making one complete rotation per second.

The LIDAR can be operated in dual mode either in traditional ground based application pointing vertically for wind resource assessment, or directed in front or behind a wind turbine to study incident wind fields and turbine wakes. The same is deployed at WTTS/WTRS, Kayathar being measured horizontal wind speed.

During the period of July to September 2011, 17 new wind monitoring stations have been established, 11 stations in Andhra Pradesh, 6 stations in Ladakh (Jammu & Kashmir). Presently, 95 wind-monitoring stations are operational in 20 states and one union territory under various wind monitoring projects funded by the Ministry of New and Renewable energy as well as various entrepreneurs.

Steps forward in TESTING UNIT

An agreement was signed between C-WET and M/s. Elecon Engineering Company Limited for Type Testing Elecon 600 kW wind turbine on 06th September, 2011 at Chettikurchi site, Kovilpatti Taluk, Tuticorin District, Tamilnadu.

Factory Instrumentation

Tower top Strain Gauging

Continuous measurements are under progress for the Type testing of 250-T wind turbine of M/s. Shriram EPC I & II at Pavoor Chathiram, Tenkasi, Tamilnadu.

Continuous measurements are under progress for the Type Testing of GARUDA 700 kW wind turbine at Melamaruthappapuram Village, in (SF.N.141/5) V.K.Pudur Taluk, Tirunelveli District, Tamilnadu.

Marching ahead in S&C UNIT

Agreement has been signed with M/s. RRB Energy Limited for renewal of Provisional Type Certificate (PTC) of Pavan Shakthi – 600 kW wind turbine model under Category- II as per TAPS-2000 (amended). Upon successful review / verification of documentation, the renewed PTC has been issued to M/s. RRB Energy Limited.

Updation process for next issue of RLMM Addendum – I to the "MAIN LIST dated 22.06.2011" has been initiated. The review/verification of documentation/information obtained from various wind turbine manufacturers are under progress.

Discussions and continuous support to software consultant in connection with RLMM Online software are ongoing.

S&C Unit has undergone the first periodic audit conducted by M/s.Det Norske Veritas for Quality Management System of Certification services as per ISO 9001:2008 and it has been successfully recommended for continuation. The continual improvement and maintaining the Quality Management System are going on.

Highlights from ITCS UNIT

7th International Training Course

ITCS unit had successfully organized the 7th International Training Course on "Wind Turbine Technology & Applications" during 03rd – 26th August 2011 to address all aspects of Wind Power starting from Wind Resource Assessment to project implementation and operations & maintenance in a focused manner. The course was attended by 26 participants from 17 different countries (Afghanistan, Bhutan, Democratic Republic of Congo, Ecuador, Egypt, Ethiopia, Gambia, Iran, Laos, Maldives, Myanmar, Palestine, Sri Lanka, Sudan, Tanzania, Thailand and Trinidad & Tobago).

Thiru. Sudeep Jain Inaugurating the function

The training course was inaugurated by **Thiru. Sudeep Jain, I.A.S,** Chairman and Managing Director, TEDA.

Participants during field visit

During the training, the participants have visited C-WET's Wind Turbine Research Station at Kayathar, wind farms near Kanyakumari, wind turbine manufacturing facility at Tada, Gummudipundi and Silvassa.

Thiru. R. Murugan distributing the course Certificate

Thiru. R. Murugan, Managing Director, TANTRANSCO Ltd. was the Chief Guest of the valedictory function. He has distributed the course certificate to all the participants after his valedictory address.

Participants in front of C-WET building

Visitors to the Campus

The following visits were arranged. A brief presentation about basic wind energy and C-WET were made for student visitors and the campus facilities were also demonstrated. The visitors were students, polytechnic teachers, delegates from foreign countries and stakeholders

- 63 students from SRM University visited on 29th September 2011
- 63 students from Hindustan University visited on 27th September 2011.
- 20 Polytechnic Teachers visited as a part of the training on "Non-Conventional Energy Sources" organized by National Institute of Technical Teachers Training and Research, (NITTTR), Chennai on 10th August 2011.
- 69 students from Sathyabama University visited on 9th September 2011.
- 6 students from Tagore Engineering College and 55 students from Central Institute of Technology, Assam, organized by The National Small Industries Corporation Limited (NSIC), Chennai visited on 13th July 2011.

Advances in SRRA Cell

To provide a solid database for solar energy deployment in India, MNRE, is implementing Solar Radiation Resource Assessment (SRRA) project through C-WET. The SRRA project mainly covers the set up and operation of a countrywide data collection system on solar radiation and meteorological parameters, in selected and identified potential areas. The current plan is to establish a network of 51 Automatic Solar Radiation Monitoring Stations spread over India, measuring direct, diffuse and global irradiance along with meteorological parameters with high quality and precision. A network of 44 Automatic Solar Radiations Monitoring Stations has already been installed, 12 in Rajasthan, 11 in Gujarat, 7 in Tamilnadu, 4 in Karnataka, 3 each in Maharashtra and Madhya Pradesh and each 1 in Pondicherry, Chhattisgarh, Andhra Pradesh and Ladakh. The Central Receiving Station, which has already been established at C-WET, started receiving data from all the stations and the remaining stations are expected to be commissioned before the end of September 2011.

SRRA is developing a new method of extended quality checks and processing of data, including corrections, gap fillings, modelling etc., to develop user friendly of data for various stakeholders. As part of SRRA project, a Calibration Lab facility will be established at C-WET to ensure high quality data of all measured parameters by calibrating the sensors on regular basis. There is also a proposal to upgrade selected 5 stations to Aerosol Measurement stations with addition of further instruments to measure aerosol data, to allow better scientific understanding of the solar radiation observations.

Spearheading in HWS

Hybrid Wind Systems unit (non - solar) was started on 16th August 2011.

Suitable activity was initiated to find out opportunities to integrate Renewable Energy systems with wind. Wind Non-Solar opportunities were explored with Barathiya Agro-Industries federation, Bangalore, which is putting up in remote areas a series of dairies. This will be further taken up to link bio-gas to get integrated with wind.

Few educational institutes have come forward to invest in Renewable Energy Technologies. Chennai Institute of Technology, Kundrathur, Chennai and Selvam Educational Institutes, Namakkal have approached and preliminary discussions indicate a good amount of work may be initiated in the coming months.

In the month of October 2011, a one day conference on WIND-SOLAR HYBRID opportunities in educational institutes will be conducted by Selvam Educational Institutes in their campus.

Invited lecture / presentation delivered by C-WET scientists in external forum / meetings / conferences

Dr.S.Gomathinayagam

Executive Director, C-WET

- Invited member in the "Clean Energy - Policy Formulation Meeting" at Secretariat organised by Govt. of Tamil Nadu on 15th July 2011.
- Delivered an inaugural speech in the 2nd International Conference on Sustainable Energy and Intelligent System SEISCON-2011" organized by Dr. MGR Educational and Research Institute – University on 20th July 2011.
- Chaired as moderator (Panel discussion) in the National Energy Investment Summit at New Delhi organized by M/s. Naseba, Bangalore on 21st July 2011.
- Attended as member in the 1st Steering Committee Meeting of "NMITLI Projects" organized by CSIR-SERC on 2nd August 2011.
- Delivered inaugural address and lectures on "Wind Energy Conversion Technology & Power Generation" and "Wind Turbine Tower Concept" in 7th International Training course on "Wind Turbine Technology and Applications" organised by C-WET during 3rd to 26th August 2011.
- A preliminary discussion on "the New Business Proposal" had with officials from Indio-Japan Chamber of Commerce on 4th August 2011.
- Attended the 4th Executive Committee Meeting of "CASR" organized by Anna University on 9th August 2011.
- Chaired as distinguished chairperson in the 5th Renewable Energy India 2011 – Expo and "Wind Resource Assessment and Forecasting: backbone to return on investment – Panel Discussion" at New Delhi on 10th August 2011.
- Attended the "Working Group Meeting" organised by Indo-Japan Chamber of Commerce on 17th August 2011.
- Lecture delivered on "Wind Energy Awareness" in the 5th Meeting of Board of Research organised by St. Peter's University on 22nd August 2011.
- Delivered a lecture on "Communal Harmony" in the Communal Harmony Fortnight Celebration of Audit & Accounts Dept, Chennai on 2nd September 2011.
- Attended in the "Award Committee Meeting" of Structural Engineering & Research Centre (SERC), Chennai on 19th September 2011.
- Delivered a lecture on "Leveraging the latest technological advancement to enable cost-effective offshore wind power generation" in the Renewcon-2011 conference at Mumbai on 29th September 2011.

WRA

Dr. E. Sreevalsan, Unit Chief,

- Meet on "Wind farm project in Kerala" along with M/s. NTPC, New Delhi and ANERT, Trivandrum at Secretariat, Trivandrum on 2nd August 2011.
- Lectures on "Wind Resource Assessment Techniques" and "Design Layout of wind farms" in 7th International

Training course on "Wind Turbine Technology and Applications" organised by C-WET during 3rd to 26th August 2011.

R. Sasi Kumar, Scientist

- Lectures on "Siting Guidelines for Wind Measurements" & "Monitoring Station Instrumentation and Installation" in 7th International Training course on "Wind Turbine Technology and Applications" organised by C-WET during 3rd to 26th August 2011.

K. Boopathi, Scientist

- Lecture on "Wind Energy Applications" to Southern State Polytechnic Lectures at NITTTR, Taramani on 9th August 2011.
- Lecture on "Wind Resource Assessment by using Remote Sensing Instruments" and "Wind Turbine Components" in 7th International Training course on "Wind Turbine Technology and Applications" organised by C-WET during 3rd to 26th August 2011.

G. Arivukkodi, Junior Engineer

- Lectures on "Measurement Parameters and Data Analysis" in 7th International Training course on "Wind Turbine Technology and Applications" organised by C-WET during 3rd to 26th August 2011.

TESTING

S. A. Mathew, Unit Chief

- Lecture on "Wind Turbine Testing and Measurement Techniques" & "Power Curve Measurements" in 7th International Training course on "Wind Turbine Technology and Applications" organised by C-WET during 3rd to 26th August 2011.
- Invited by Vel Tech Technical University in the capacity of an expert R&D member for their EEE faculty R&D review meeting held on 9th July, 2011 at Vel Tech Dr. RR & Dr. SR Technical University, Chennai.

M. Anwar Ali

- Lecture on "Safety and Function Test" & "Load Measurements" in 7th International Training course on "Wind Turbine Technology and Applications" organised by C-WET during 3rd to 26th August 2011.

S & C

A. Senthil Kumar, Scientist & Unit Chief

- Delivered lecture on "Type Certification of Wind Turbines" in 7th International Training course on "Wind Turbine Technology and Applications" organised by C-WET during 3rd to 26th August 2011.

N. Raj Kumar, Scientist

- Delivered lecture on "Design aspects of Wind turbine Gearbox" in 7th International Training course on "Wind Turbine Technology and Applications" organised by C-WET during 3rd to 26th August 2011.

S. Arulselvan, Junior Engineer

- Delivered lectures on "Design requirements of Control and Protection System" and "Design aspects of Wind Electric Generators" in 7th International Training course on "Wind Turbine Technology and Applications" organised by C-WET during 3rd to 26th August 2011.
- Delivered a lecture on "Wind Turbine Technology" as part of the one day seminar on "Green Energy for Empowering India" held at United Institute of Technology, Coimbatore.

ITCS

P. Kanagavel, Scientist & Unit Chief (i/c)

- Delivered a Lecture on "Energy & Environment for Knowledge Society" in the UGC refresher course organized by UGC Academic Staff College & co-ordinated by the Department of library & Information science, Bharathidasan University, Trichy at UGC Academic staff college, Kahajamalai Campus, Bharathidasan University, Tiruchirapalli on 19th September 2011.
- Delivered lectures on "Environmental aspects of Wind Turbine Technology" and "Role of C-WET in Wind Energy Development" in 7th International Training course on "Wind Turbine Technology and Applications" organised by C-WET during 3rd to 26th August 2011.

Publications

- Published a paper on "A Scientometric Assessment of Wind Energy Research productivity: A Global Perspective" at COLLNET 2011 An International Conference organized by Istanbul Bilgi University, Istanbul, Turkey during 20th to 23rd September 2011.

WIND POWER STORAGE FOR SUSTAINABILITY

Dr.S.Gomathinayagam, Executive Director, C-WET, E-mail: ed@cwet.res.in

INTRODUCTION

The source of energy can vary but it is well known that the validity of Newton's law cannot be disputed, which states that energy can neither be created nor be destroyed. We know that Wind is air in motion. This motion of air happens due to several complex geographical, topological, and weather related parameters. But it should be remembered that only 2 to 3% of solar radiation absorbed on earth's widely varying surface causes the Wind by convective circulations between Polar Regions and Equator Regions, from hill to valley, from the ocean to the land... and so on. Earth's rotation adds to wind's kinetic energy fluctuations. Today the mitigation of climate change effects relies on use of renewable energies and Wind is one of the major and abundantly available sources of green energy.

Stand alone Power

Even though wind can be utilized directly for various energy needs of human activities, such as sailing ships, water pumping, and grain processing, if wind energy is converted to the most common form viz. electrical energy, then in today's world the utility is almost for all the purposes/ applications. Wind energy can be converted to electrical energy in two modes, (i) the standalone or captive use of power. (ii) Grid connected .


Grid connected power

Fig.1 Utility modes of Wind Electric Power.

Electric power (Fig.1). In the former case the Wind Electric Generator (WEG) is used for domestic application as the electric power generated is consumed in the house itself. In the case of Grid connected utility of wind electric power, the generated power is fed to the state electricity Grid for transmission and distribution to the community at large. The mode of grid connected wind power generation is becoming popular and has become quite matured as a reliable technology even though wind as a resource at any given site is always uncertain and so is the infirmity of Wind power

Wind Electric Generation: A Scenario

Globally installed capacities of WEGs have crossed 200 GW. Indian electrical energy generation industries have a total installed capacity of 184 GW of Electricity generations as on date, of which about 20 GW is from all Renewable Energy Sources in which about 15 GW is from Wind Energy. Wind is one of the fastest and most viable Renewable energy technologies. In India, the annual capacity addition per year, in 2010-11 is currently about 2300 MW. India also has about 1MW of wind-solar hybrid domestic system which are mostly used as standalone applications.

India with 15GW ranks 5th in Wind power installed capacity as on date, following China USA, Germany, Spain. (1 Giga watt = 109 watt) In the Indian wind power development, the primary driving factor has been feed in tariffs (FIT) and accelerated depreciation and other tax incentives for domestic wind systems. Hence most of the investors in Wind Energy, are all from the Private Sector, Apart from the demonstration projects of State and Central Governments

Table.1. State wise installed capacity of Wind Power in India.

Sl.No.	State	Installed Capacity in MW
1	Andhra Pradesh	200+
2	Gujarat	2975+
3	Karnataka	1730+
4	Kerala	32.8+
5	Madhya Pradesh	275.5+
6	Maharastra	2310+
7	Rajasthan	1525+
8	Tamil Nadu	6300+
	India	14869+ (as on 31-08-2011)

Today there are more than 3500 wind farm owners having capacities of WEG (Wind Electric Generator) from 225 kW to 2100 kW and most of the owners have bought either from Vendors (system integrators) or manufacturers having joint

ventures or licensing agreement with Foreign collaborators mostly of European origin. State-wise installed capacity is given in Table-1

India has got an ambitious plan to exploit in full, the wind energy potential in the Country which based on just a nominal 2% land availability in the windy areas, is estimated to be 49 GW at 50m level of which only 28% has been exploited as on date. However, this potential can be shown to be different and may be many folds, with upward changes in land availability and the hub-height from ground level of modern large multi-mega watt WTGs.

Indian Scenario

As on date, in India a site which has more than 200 watts per square meter as Wind Power Density (WPD) which deemed to be economically viable so far is removed. With recently picked up micro wind generation i.e. to exploit urban wind areas and low wind areas and to facilitate remote village electrification domestic wind mills of 0.3 kW to 50 kW are being adopted. This micro wind generation as on date has a low market demand since it has been mostly developed as a standalone system which is often not grid connected.

Another important issue in any country involved in wind power development is development of infrastructure facility in wind farmable areas such as roads and logistics for larger machine components to reach windy Regions. Other infrastructural facilities for establishment of human habitation in wind farm and establishment of electrical grid for evacuation of the power generated by the wind turbines. Most of the State and Central Government have been concentrating on these infrastructural developments and hence wind power in India has become more viable and the growth is sustained at the global rate of more than 20% every year.

Wind Electricity Generation (World)

Wind electricity generation has been steadily increasing in some countries and world leaders being, Denmark 21% energy penetration, Portugal 18% , Spain 16% Germany 9% , India 3-4% , USA 2% and China 1.2% . Wind as a fuel for electricity generation is free, pollution free, completely renewable, devoid of the need to transport/ store and is cheaper than gas-based generation in India Tamil Nadu has the highest level of penetration in installed capacity to the tune of 55% of the net conventional base power generation capacities. In a local region (Tamil Nadu), if electrical energy penetration is considered in a typical wind season it will be about 20% of the electrical energy generated by conventional means which is comparable to the country's scenario of penetration of wind energy in Denmark.

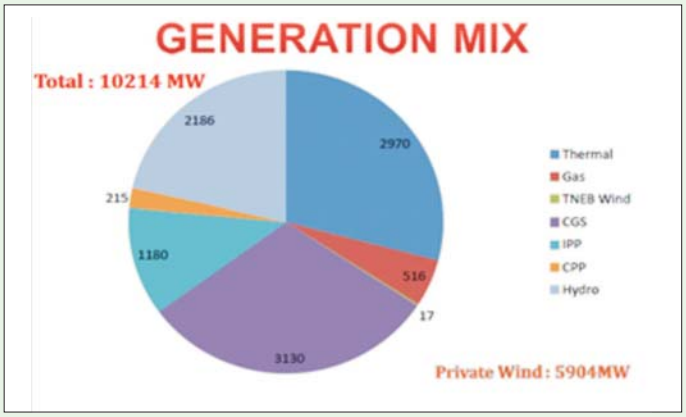
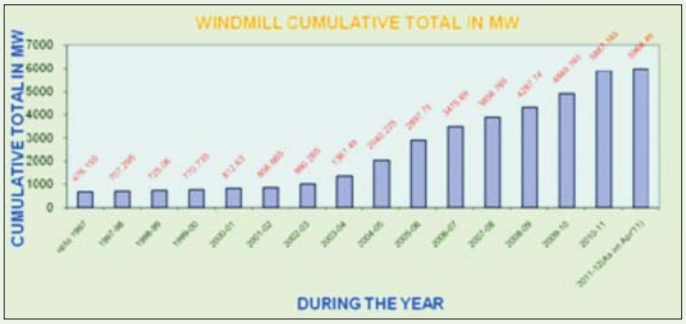


Fig.2 Indian regional high wind generation mix (Tamil Nadu)



The only difference between the Denmark and Tamil Nadu as an Indian region are the characteristics of their Grid and power quality in the grid. Typically Denmark has a very stable sustained GRID while Tamil Nadu has weak grid characterized by frequent power fluctuations (voltage as well as frequency) and grid –outages due to instability and forced shutdowns. To tackle this serious problem of backing out wind farms by forcing power shutdowns by the utility distribution companies (DISCOMS), there is a urgent need to look out and research on the various storage techniques to store the excess power generatable from wind energy and overcome the infirmity of wind power, thus ensuring sustainability.

Infirmity and Sustainability of Wind Power:

Infirmity

It is well known that wind is natural and is infirm power and the implications of infirmity are:

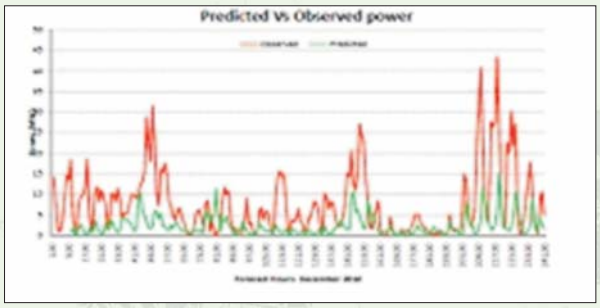
- Wind power cannot be scheduled
- Needs a spinning reserve or alternate power

- Wind generators bank energy and demand during peak hours
- Electricity Board pays for both base power purchase and wind generation
- Grid stability & low voltage, high frequency due to wind farm operations
- Needs research for economic storage to avoid wastage of free wind power

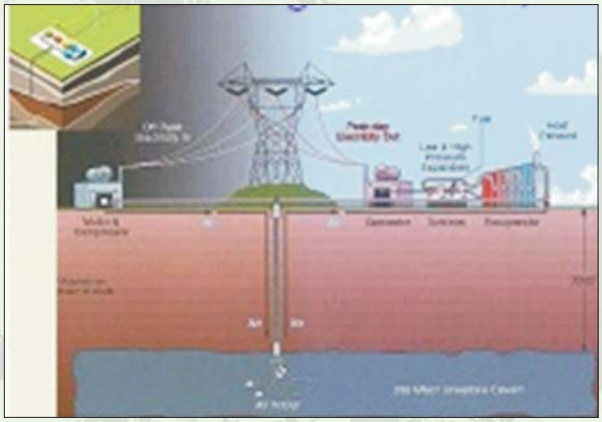
Weather triggered random wind and wind generation can be forecast to make the infirm power as dispatchable firm power that is one other way to sustainability other than energy storage systems

Sustainability: Energy Storage Systems

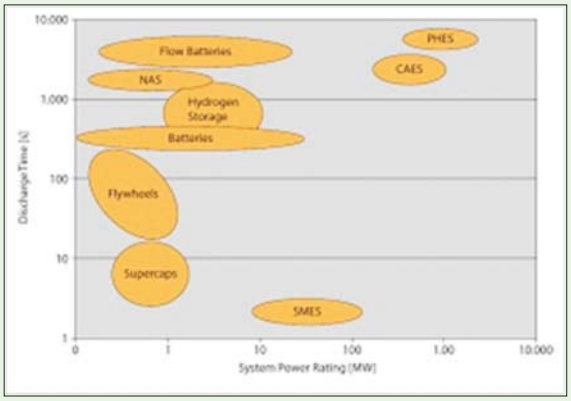
In Fig. 3 different methods of overcoming the infirmity of wind by effective forecasting and storage techniques are indicated. Some successful energy storage techniques such as Pumped Storage Hydel (PSH), Compressed Air Energy Storage systems(CAES, USA) and a kind of flow battery or Sodium Sulphur (NaS, Japan) systems at world's wind farms are proven to be practical solutions as reported in an excellent review of energy storage technologies for Wind Power projects (Swierczynski, M. et al., 2010). The paper gives an overview of all kinds of Energy storage systems which under research as well as in practice all over the world, for increasing the penetration level of wind or any other renewable resource which may be infirm or unpredictable with certainty.



Infirm made firm by wind forecast

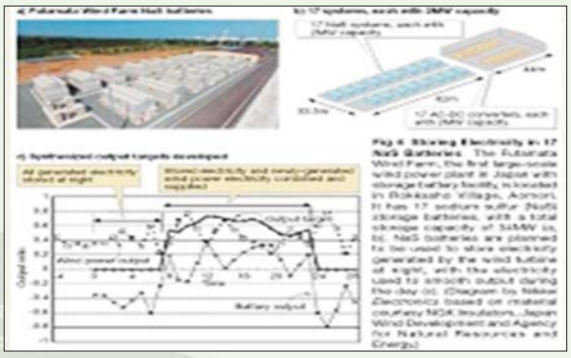


Compressed Air Energy Storage (CAES)



Pumped hydro energy storage (PHES)

NaS/Flow-Battery bank energy storage



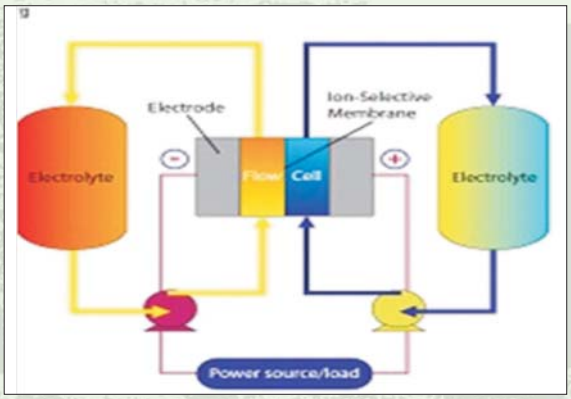


Fig.3 Overcoming Infirmity of Gird connected Wind generation

Sustainability-Using in Electrically Operated Vehicles (EOV) / Storing hydrogen

Where wind power is in excess provide charging points in every parking area in the house, office, industry, institutions, public places where any EOV , electric car's battery can be charged to create that extra load that is needed when excess power is generated in the grid by wind. Focussed approach to increase the EOVs and use the resources smartly to manage the Grid using demand side management tools. This enables storage of natural energy from Wind in EOVs thus giving carbon reduction, emission /pollution reduction the utility gets paid for every unit produced and used for charging EOVs. Modern cars are designed to have multiple fuels including fuel-cells and hydrogen energies. Projects are on to produce and to store hydrogen in community overhead reservoirs/tanks instead of water using excess renewable power generated for domestic and EOV applications in the community.

Sustainability-Wind to water

It is well known that wind is certainly an inexhaustible abundant source of energy which is caused by the differential solar radiation on the Earth's geo-diverse surfaces, having different degrees of absorption/reflection/ refraction/convection/transmission. Wind power is not only a renewable green source of energy; but also results in significant saving of potable/drinking water, which is much needed for human survival. Electricity generation by wind consumes only of fresh drinking water that is used by nuclear/oil/coal based thermal plants. Thus wind energy usage for electricity enables sustaining water which is becoming scarce day by day.

Texas Technical University, TTU, Lubbock, Texas, USA has successfully demonstrated through a focused project of small wind generator being used for desalination of sea water to provide potable water. A dream of this by every human would solve the much needed water for greening our long Indian coast line of 7650km, providing livelihood with non polluting power.

Sustainability-Small Wind Power shared in Grid

Small domestic wind generations would literally be possible most of the moderately windy sites spread all over India the affordability of an electrical inverter to tide over power cuts is quite common these days when a family goes for a new house or flat. Why should we not resort to charging the inverter with infirm wind/Solar power, to save power for someone who lives elsewhere waiting to get power? When both /all the members of a family go to work such roof top Small wind Energy systems (SWES) with wind solar hybrids as well can pump.

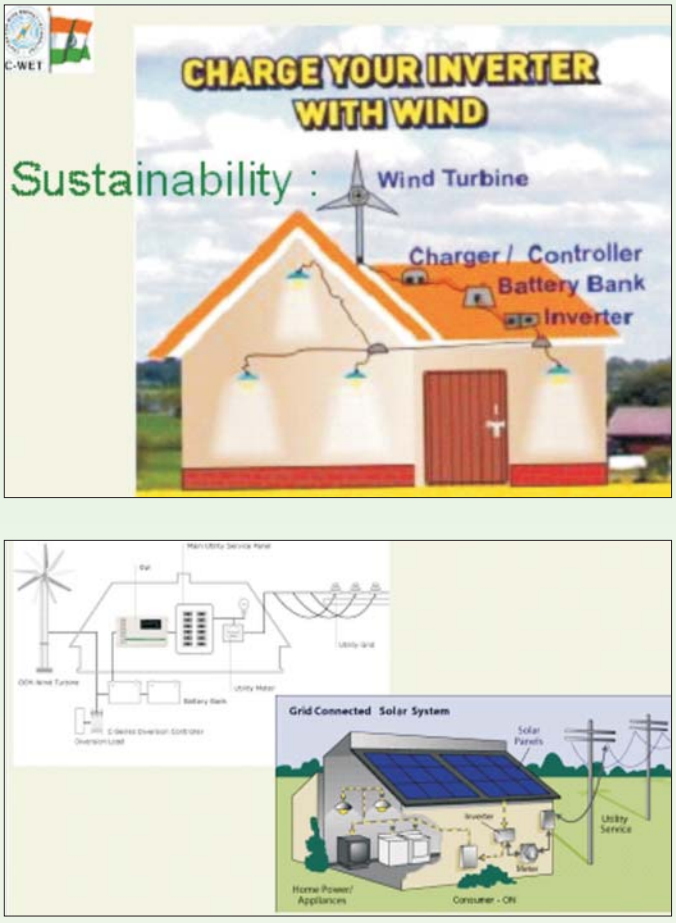
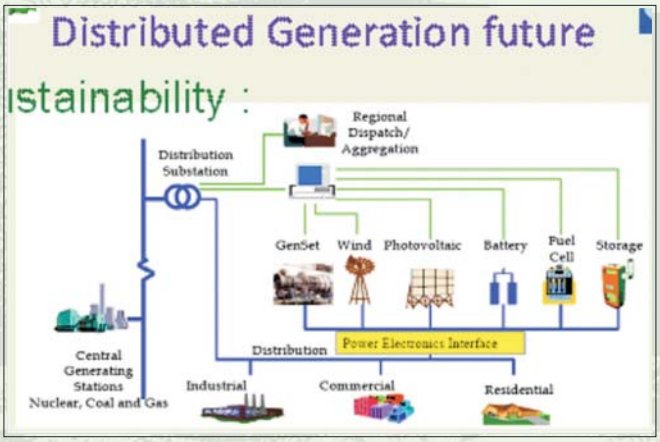


Fig.4 Sustainable Development with off-Grid and On-Grid wind power

Sustainability-Distributed Generation and demand side management of Power.

In countries where even fossil fuel needs to be air lifted for want of improper roads and lack of grid connected electricity, the modern concept of distributed generation (Fig.5) and local usage with microgrids will certainly give sustainability and feasibility of wind power with regional advantage.



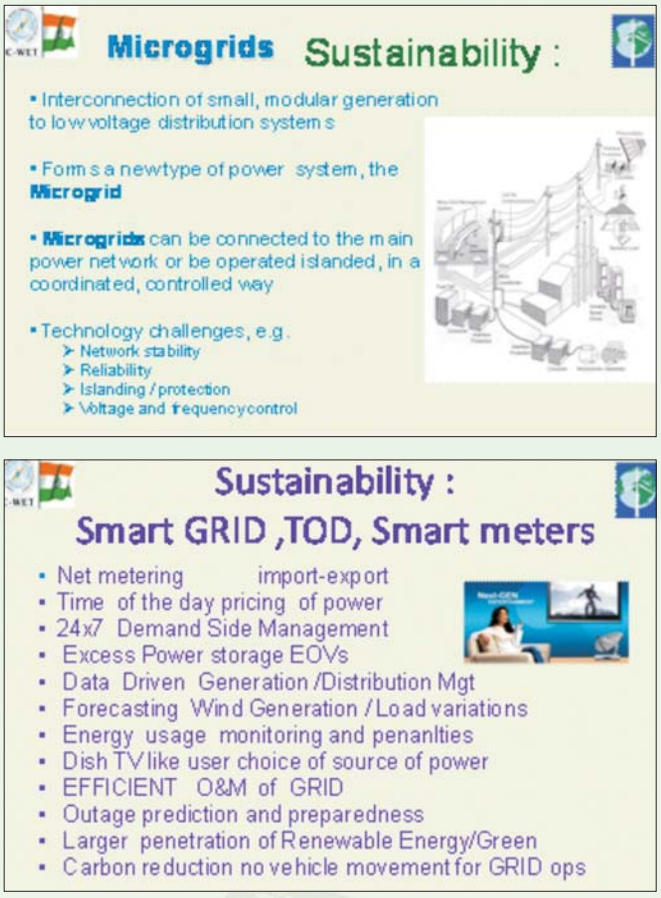


Fig.5 Sustainability with distributed generation, islanding and smart grids

Summary

The review paper cited as reference shows possible energy storage(ES) systems as Pumped Hydro (PH), Compressed Air (CA), Flywhell(F), Supercapacitor(S), Superconducting Magnet(SM), battery systems such as Lead Acid(LA), Nickel Cadmium (NC) , Lithium Ion (LI), Sodium Sulphur (NaS), Flow Battery (FB), and hydrogen (H). The work also identifies PHES and CAES as geologically constrained, and apparently pointing needed research to reduce cost of LIES, NaSES, FBES and HES technologies for promoting higher wind penetration. The briefing paper by Petra de Boer and Jillis Raadshelders of Leonard Energy in KEMA 2007 gives a vivid description with practical value for having firsthand information on flow battery systems.

The much needed spinning reserves as well as Grid regulation and safe controls, **when wind penetration is very high such as in Tamil Nadu for** complying to the Grid frequency, LVRT, voltage controls, forecasting wind generation, to overcome flickers and outages and to have supply for auxiliary power supplies to maintain wind power projects operational management systems of WTGs the Energy storage solutions would be very much needed at a much affordable extra cost for the wind farm developers.

Reference/Acknowledgements/Courtesy

www.leonardo-energy.org; www.tnebnet.nic.in; www.tnercnet.gov.in ; cwet.res.in

Swierczynski, M., (2010) Teodorescu, R., Rasmussen C.N., Rodriguez P., and Vikelgarrd H., "Overview of the energy Storage Systems for Wind Power Integration Enhancement".

978-1-4244-6392-3/10, IEEE 2010 pp 3749-3756.

Petra de Boer and Jillis Raadshelders "Briefing paper- flow batteries", Leonard Energy in KEMA 2007 www.leonardo-energy.org.

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Velachery - Tambaram Main Road, Pallikaranai, Chennai - 600 100.
Phone : +91-44-2900 1162, 2900 1167, 2900 1195 Fax : +91-44-2246 3980
E-mail : info@cwet.res.in Web : www.cwet.tn.nic.in

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