Indian Wind Power

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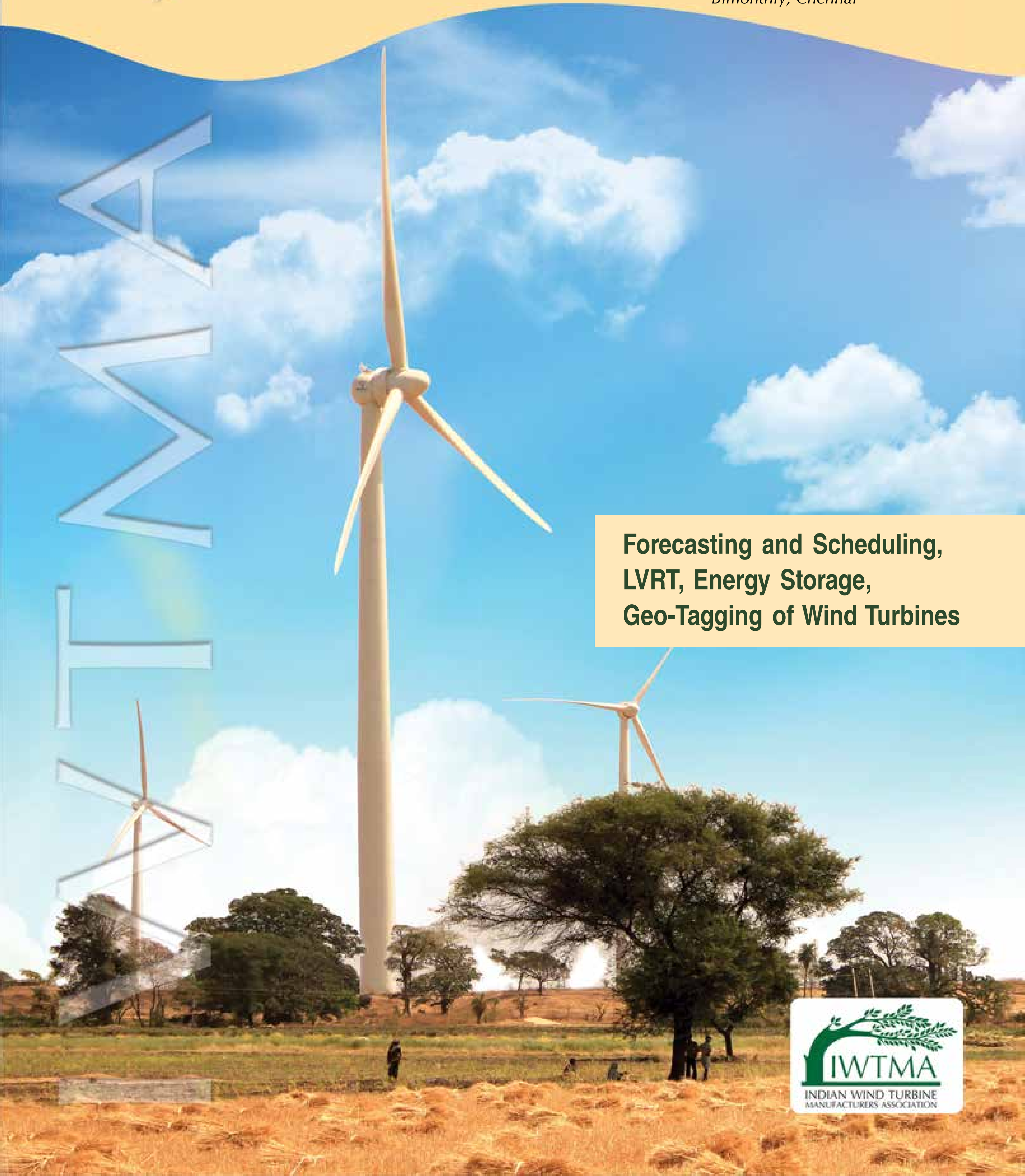
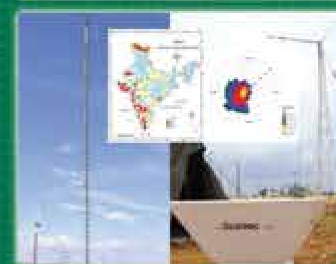


Forecasting and Scheduling, LVRT, Energy Storage, Geo-Tagging of Wind Turbines

IWTMA
INDIAN WIND TURBINE MANUFACTURERS ASSOCIATION

Expertise offered to Wind & Solar Energy Stakeholders



Wind Resource Assessment

- Carry out Nationwide Wind Resource Assessment
- Estimation of Wind Potential in the country through Wind Atlas preparation
- Design and implement the comprehensive Resource Assessment Programme
- Analysis of wind data to identify Wind Farmable locations
- Verification and vetting of wind data generated by private entrepreneurs
- Consultancy services for Feasibility Studies, Technical Due Diligence, Micro siting and preparing DPR for Wind Farming and Repowering assessment

Offshore Wind Energy

- Nodal Agency for facilitation of clearances for Offshore studies and surveys
- On-site wind measurement campaign
- Demarcation of potential Offshore wind blocks
- Call for proposal for development of Offshore wind energy blocks
- Promoting indigenous research for technology development

Testing (Large & Small) & Forecasting

As per Internationally accepted procedures and stipulations for

- Power Performance measurements
- Load measurements
- Power Quality measurements
- Safety and function tests
- Yaw efficiency test
- User defined measurements
- The services are not limited by type or size of the Wind Turbines

The services are certified as per the requirements of ISO 9001: 2008 and accredited as per the requirements of ISO/IEC 17025 : 2005

- Wind Power Forecasting Services
- Duration Test

Standards & Certification

- Preparation of Indian standards on wind turbines
- Accord Type Approval / Type Certification to Wind Turbines. Type Certification Services are certified as per ISO 9001 : 2008
- Issue the recommendation for grid synchronization to facilitate installation of prototype wind turbines
- Supports Multi institutional research on Wind Energy

Training

- National, International and Customized Training for various types of clients on
- Wind / Solar Resource Measurement & Analysis
- Wind / Solar Technology

Solar Radiation Resource Assessment

- Solar Radiation Resource Assessment
- Consultancy on solar energy projects
- Investor & bankable grade solar / meteorological data
- Consultancy on solar resource assessment
- GIS enabled Indian Solar Atlas on website
- Calibration of solar sensors
- HR training on solar energy under PPP mode
- Solar Power Forecasting Services

"Give a missed call on toll free number 18002003004 to get our apps."

NATIONAL INSTITUTE OF WIND ENERGY

An Autonomous Research & Development Institution under the Ministry of New and Renewable Energy, Government of India

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IWTMA
INDIAN WIND TURBINE MANUFACTURERS ASSOCIATION

Indian Wind Power

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Volume: 4 Issue: 1 April - May 2018

Contents

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(For Internal Circulation only)

From the Desk of the Chairman - IWTMA

Dear Readers,

Greetings from IWTMA!

The Wind Industry witnessed a temporary drop in volumes in Financial Year 2017-18 (FY18) due to its transition from the feed-in-tariff (FiT) to the competitive bidding regime that brought down wind installations to the tune of 1762 MW, while the cumulative installation reached to 34,132 MW by the end of this fiscal year.

However, the industry is now on a fast-growth trajectory with a healthy order pipeline, due to auctions by Solar Energy Corporation of India (SECI) I, II, III, IV (6,050 MW) and state level bids in Tamil Nadu, Gujarat and Maharashtra (1500 MW). With SECI V and NTPC bids coming up, another 4 GW is expected to be auctioned soon.

Incidentally, the volumes are set to grow exponentially with ~10 to 12 GW auctions each year from SECI and state bids combined, as well as from projects less than 25 MW based on a determined tariff. At the current rate, the wind industry is on course to add ~30GW of new capacity in the next three years, thereby taking the cumulative total capacity to ~60 GW ahead of its 2022 target set by the Ministry of New and Renewable Energy (MNRE). The wind industry is a testament to the 'Make in India' initiative for more than two decades.

Also, there is a clear visibility of continuous volumes in the coming years that shall allow a gradual stabilization of tariff, as evidenced in the SECI IV auctions where tariffs firmed up at Rs 2.51 per unit, higher than the earlier SECI bids. The tariffs will also depend on wind regimes in different states. Technological innovation plays a big role as manufacturers are working towards bringing down the Levelised Cost of Electricity (LCOE) and increasing Plant Load Factor (PLF).

Clean energy has now become a reliable, affordable and mainstream source of energy. The wind industry is determined and focused on enabling India's energy security, affordable energy for all and transition to a low-carbon economy.

Other thrust areas are in wind solar hybrid, repowering and beginning of off-shore wind as signalled by MNRE. We appreciate the announcement of Expression of Interest for 1 GW of Off-shore in the State of Gujarat.

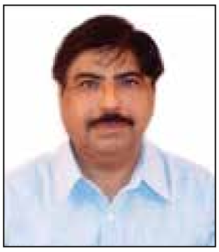
The current issue covers extensive reads on geo-tagging of wind turbines, wind scheduling and forecasting, storage and LVRT.

I also take this opportunity to wish our readers continued success and best wishes for the New Financial Year (FY. 19).

With Best Wishes

Tulsi Tanti
Chairman

Scheduling and Forecasting in Rajasthan - Initiative of IWTMA



O. P. Taneja, Associate Director
Indian Wind Turbine Manufacturers Association, New Delhi

Scenario of Rajasthan, 2016

- Only partial Forecast data available with SLDC.
- SLDC not equipped for analysis of deviation between scheduled wind power and actual injection.
- No Data integration system in between pooling substations and SLDC for getting the details of power injection at any time.
- SLDC used to get data on phone and manually maintain a log book, which is not reliable as the data is received at different times, hence are not comparable.
- Availability of actual data of Injected Power is possible only after 30 days from the MRI record.
- SLDC is in the process of installing fibre optic communications from Pooling Substations to Inter Connection Substations, which will take around 4 years.

Forecasting & Scheduling – Coordination by IWTMA

- IWTMA is playing a role as a single co-ordinating agency for compiling all data as received from various developers/generators and forwarding to SLDC.
- Approx. 4246 MW Zero revision forecast data on Day ahead basis is being forwarded to SLDC before 10:30 AM daily. This is followed by 16 revisions as per regulations.
- IWTMA engaged REConnect Energy as System Integrator for making the exercise dynamic and analytical.
- System Integrator will be responsible for installing ABT meter with Dual SIM based GPRS Modem in all the polling substations. The modems will work on storage & forward concept.
- System Integrator will also install RTUs in pooling substations with a dedicated Gateway at SLDC to synchronize all RTUs in SLDC System as per their requirement.

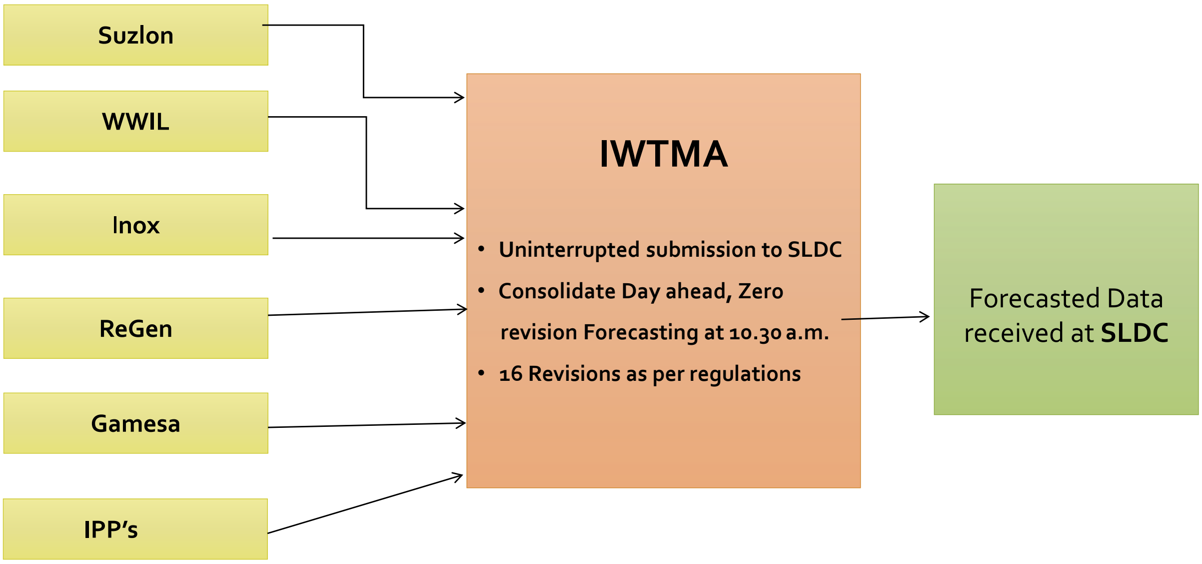


Figure 1: Present Status

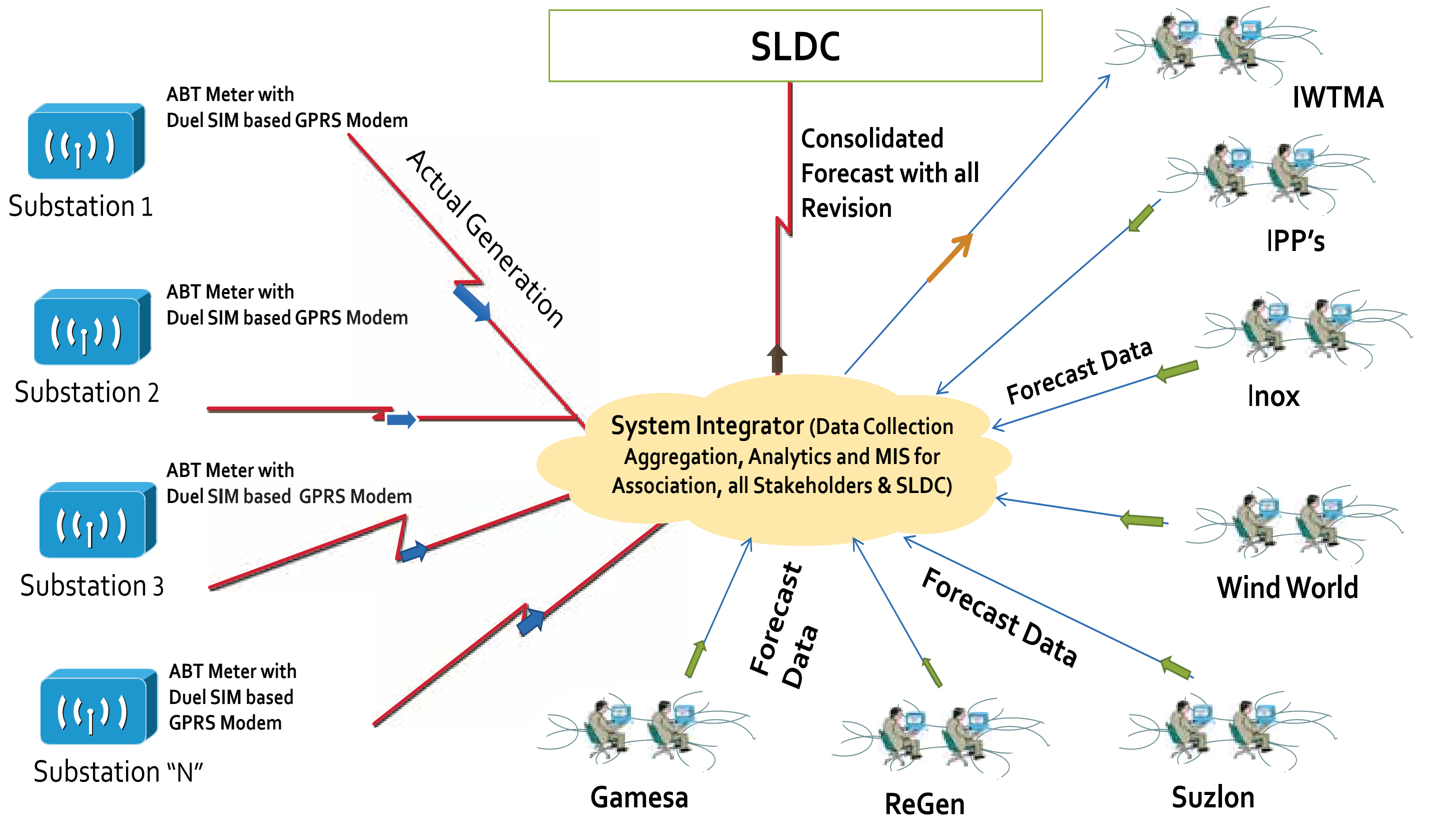


Figure 2: Working Architecture: For ABT Meter Data Acquisition & Role of System Integrator

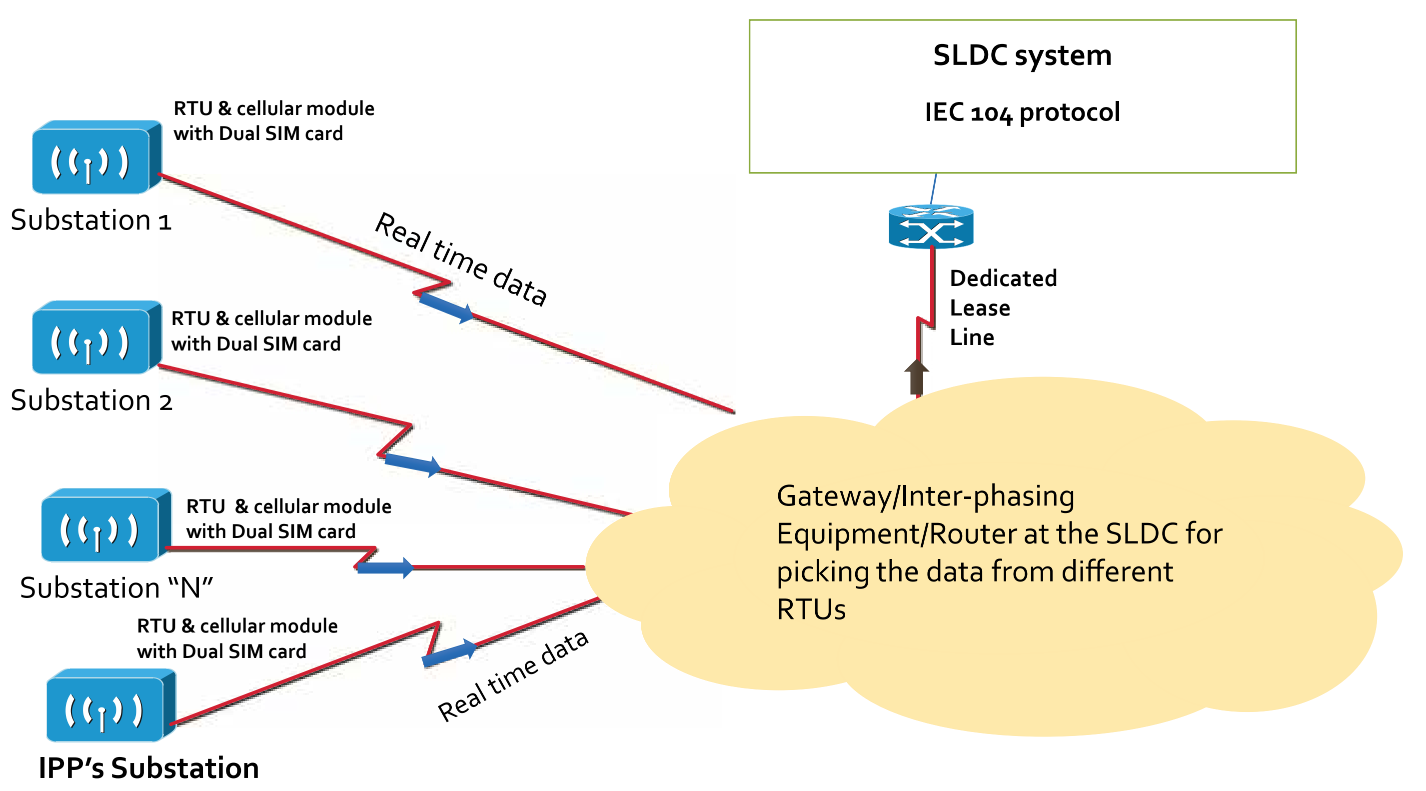


Figure 3: Data Transfer Architecture: From RTU to SLDC

Scope of System Integrator

- ➢ Maintain the Communication system for transfer of data from ABT meters to Developer/Generator and SLDC.
- ➢ Maintain the RTU/Data Acquisition System and Gateway/ Inter-phase equipment at the SLDC.
- ➢ Compilation of forecast data including all revisions, as per regulation and submit to SLDC.
- ➢ Co-ordination with SLDC, RDPPC, Substations, Developers/ Generator or any other designated agency.
- ➢ Prepare periodic reports covering analysis, issues of curtailment, actual vs forecasted deviation, etc.
- ➢ Reports and Management Information System for SLDC/ OEM/ Developers/Generators or any designating agencies.

Status as on Date (Hardware & Software)

- ➢ **ABT Meters (L&T Make) and Dual Modems (iMDAS** by REConnect Energy) installed at all Pooling Substations and streaming real-time data to SLDC.
- ➢ **8 RTUs installed with dual-modem** and some of the pre-existing RTU's are streaming data to **dedicated wind energy gateway** installed as SLDC.
- ➢ **7 different OEMs being integrated** into the system from the hardware and software point of view (Suzlon, WWIL, ReGen, INOX, Gamesa, Greenko, Tata/Welspun).
- ➢ SLDC Rajasthan and IWTMA having a real-time access to data (static and power) through a **state-of-the-art web-application (GRID Connect).** Each other stakeholder has access through password for their own data.

Status as on Date (Forecasting & Scheduling)

- ➢ **Forecast - Aggregation & Scheduling**
  - Data received from multiple forecasters is being aggregated and sent to SLDC.
  - Daily 36 PSS (4246.75MW) are sending day-ahead forecasts.
  - Daily 36 PSS (4246.75MW) are sending intra-day forecast revisions.

(16 revisions)

- ➢ **Real Time Generation Data**
  - Daily 3456.35 MW actual generation data is beamed to SLDC through Gateway installed at SLDC. The work is in progress for the balance capacity of 790.4 MW

Reports Generation and Download Options

Following reports can be downloaded from the portal, in Excel (csv) & PDF Format.

Can also be copied & printed

- ➢ Current Day's Aggregated Day Ahead Forecast, Revised Forecast and Actual Power Generation.
- ➢ Next Day's Day Ahead Forecast Pooling Substations wise.
- ➢ Historical Aggregated Revised Forecast and Actual Power with date selection option.
- ➢ Current Day's Region wise Aggregated Revised Forecast and Actual Power Generation
- ➢ Pooling Substations wise Forecast vs Actual generation
- ➢ Static Details Pooling Substations wise with project status.

Figure 4: Web-application (Real-Time FC vs. Actual State Level)

Figure 5: Web-Application (Regional Break-up of Actual Generation)

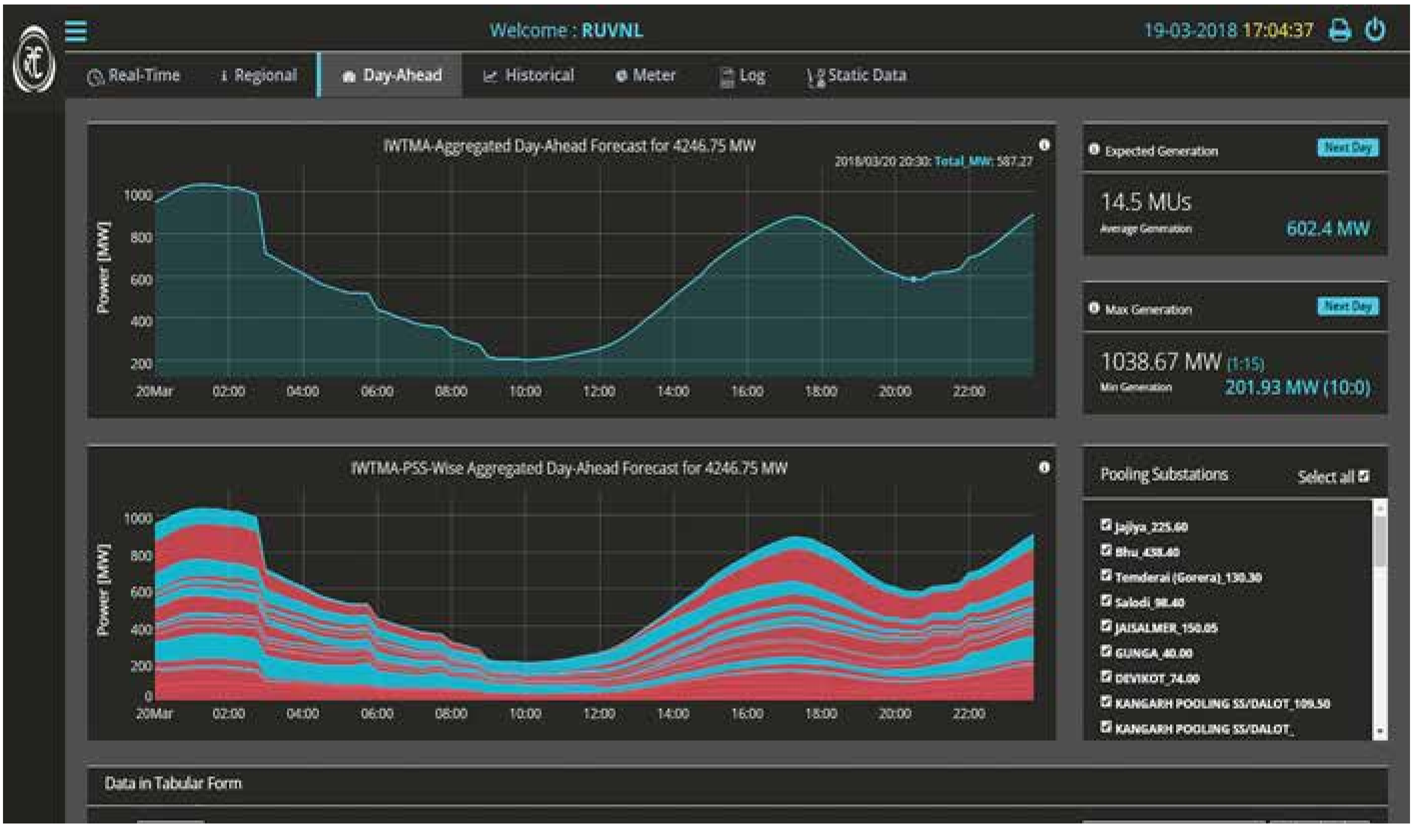


Figure 6: Web-Application (DA Forecast with each PSS Level Break-up)

Figure 7: Web-Application (Historical Data and Accuracy MIS)

Installed Capacity of Wind Power in Rajasthan

As on 31/04/2017

Developer	Jaisalmer	Jodhpur	Sikar	Barmer	Chittorgarh/ Pratapgarh	Total
RRECL	45.4	2.1			2.25	49.75
Suzlon	1608.95	315.5		9.6		1934.05
WWIL	896.77	98.4	7.2			1002.37
NEPC	0				0.675	0.675
RRB	25.8					25.80
Veer	76.5					76.50
Regen	0				211.5	211.50
Inox	554					554.00
Welspun	0				126	126.00
Gamesa	0			40		40.00
Mytrah	62.9					62.90
Tanot	120					120.00
Rajgarh	74					74.00
Others					15	15.00
Total	**3464.32**	**416**	**7.2**	**49.6**	**355.425**	**4292.545**

Statistical Approach to Improve Prediction Capability of Condition Monitoring Systems

Fabrice Drommi, Machine Health Business Development
Renewable Energy, SKF. fabrice.drommi@skf.com

SKF applies statistical techniques to the workflow and data from individual turbines in order to achieve effective fleet analysis. Furthermore, the global database can be leveraged for enhanced decision guidance. Diagnostics are shown here from two case studies performed on challenging planetary gears.

Conclusion: To do an efficient job on a majority of the drive-train failure modes, you need to take an individualized approach to vibration monitoring for each wind park being managed. The alarming process provides efficiency, while advanced diagnostic techniques help to reveal the more complex issues.

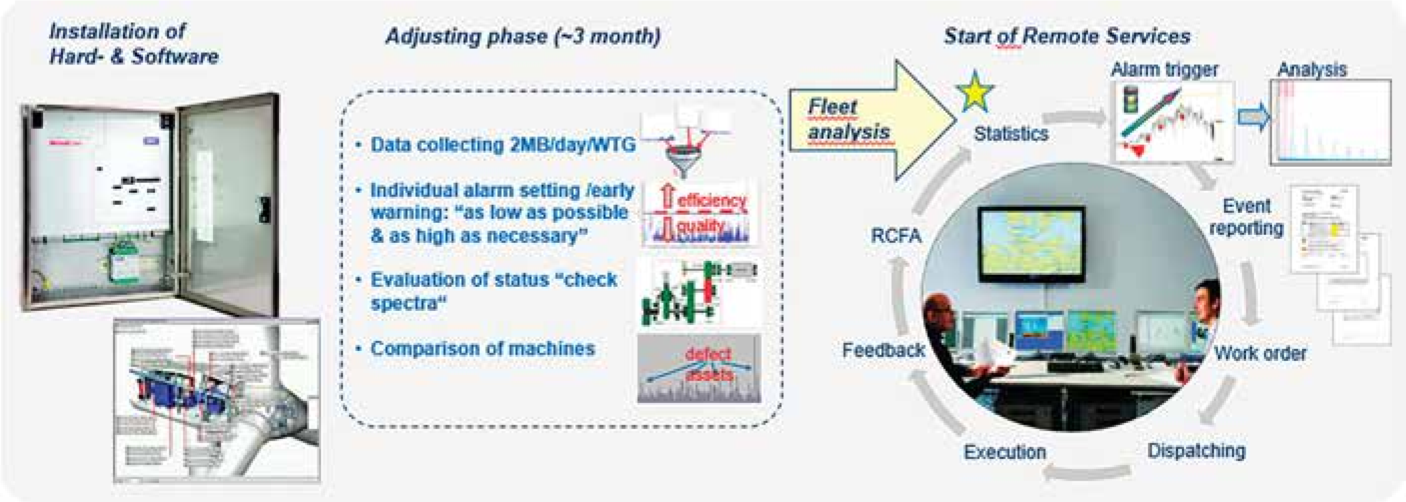
1. SKF, CMS & Remote Monitoring

We manufacture numerous components including different bearings for the drive train, along with lubrication and sealing solutions. Ten years ago we developed a vibration monitoring system and opened a remote monitoring center.

Condition monitoring is the process of determining the condition of machinery while in operation. The key to a successful condition monitoring program includes knowing what to listen for, how to interpret it and when to put this knowledge to use.

Condition Monitoring Systems (CMS) not only help wind farm operators reduce the possibility of catastrophic failure, but also allow them to order parts in advance, schedule manpower and eventually crane, and plan other repairs during the downtime.

Our Remote Monitoring Services use SKF condition monitoring tools such as the SKF IMx on-line system dedicated to Wind Turbines (so called Windcon) to collect data. Based on further analysis, experts interpret the results and communicate with wind park operators to serve informed decision-making in the management of machine health.

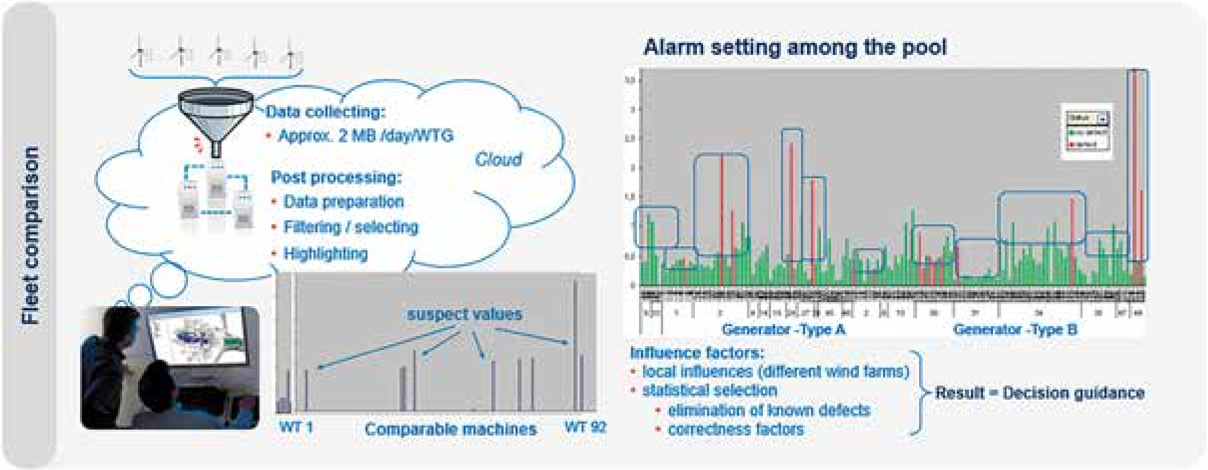


2. Turbine Adjustment/Fleet Analysis

The volume of data collected from a large wind farm is staggering. Typically there can be eight sensors on a geared wind turbine, each with three measurements; 24 indicators in total (one indicator is one spectrum and one overall value). This information is collected by the condition monitoring hardware and is sent over the internet, either wired or wireless, to a CMS server, which can be located anywhere on the planet.

In one year with an average of one download a day we have close to 9,000 spectra to analyze. If you imagine at the scale of a wind park, which could contain hundreds of turbines, it is apparent that traditional analysis techniques would not be economically applicable. That volume of data means that we now have to use a statistical approach to analyze the data.

This is used to compare the turbines between each other as much as possible given differences in location and models. First we compare what is comparable and then we use the historical data we have amassed over the ten years of monitoring wind farms of different models. Based on this history of the data, dependent on turbine type, we use this as background for the new machine that we start to monitor.



3. Fleet Comparison

The aim now is to broaden the fleet analysis perspective within the global background that we have, built up from among some 2000 turbines monitored within SKF group. Since the wind turbine is a complex machine, with a great many variables, we cannot simply apply one model of alarm level to all machines. So, we have to develop individual alarm models that allow us to rapidly evaluate the machines, being guided by the statistics, filters and selection.

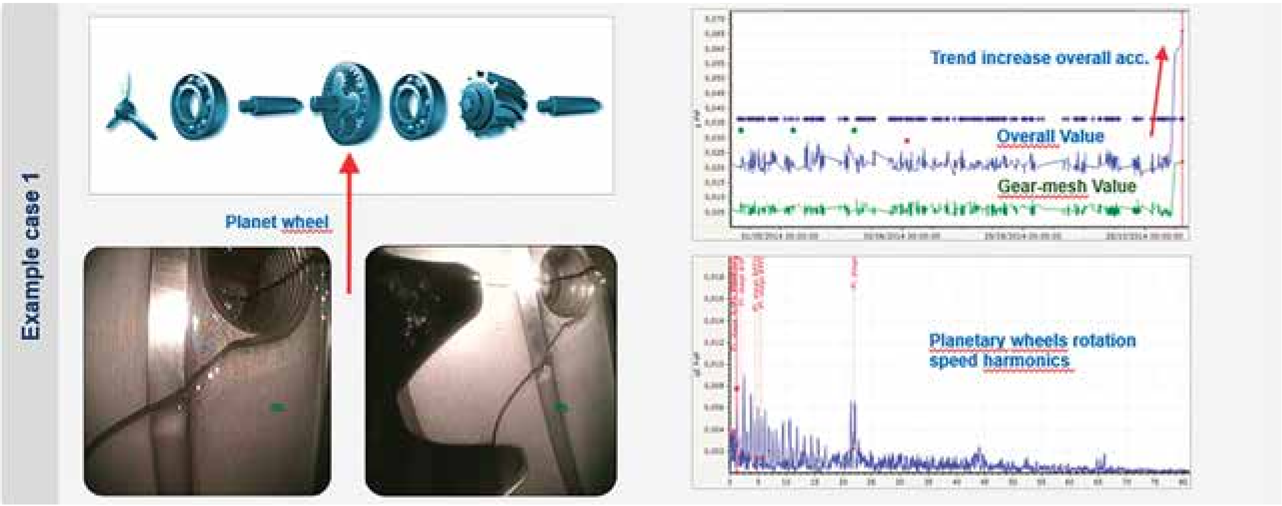
It is vital to select the right kinematic data to analyze, to help and to increase the process accuracy. The system has some features that enable it to scan for potential theoretical faults. To do this automatic scanning you need to rely on the actual information on the type of components in the system. Each gear has its own characteristic frequency, so achieving effective detection puts high demands on having correct knowledge about the kinematics inside the turbine. Today, given our extensive historical database, we have a good understanding and good background on the components inside the gearbox and inside the generator.

Based on our experience, not all the components in wind turbines need the same level of expertise to be analyzed. Detecting a generator with bearing issues is relatively easy, but planetary bearings and gears present a greater challenge. We have developed specific algorithms that are really focused on the detection of the planetary gears themselves.

4. Examples of Monitoring & Diagnostics

Here are two examples collected from field experience. They analyze the complex nature of vibrations originating from the planetary stage, especially the gears, which are generally regarded as the most challenging components to diagnose.

Case 1:




Sustainable development, supported by Suzlon.
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We're proud to demonstrate our commitment towards sustainable development across our 15 manufacturing locations across the globe.
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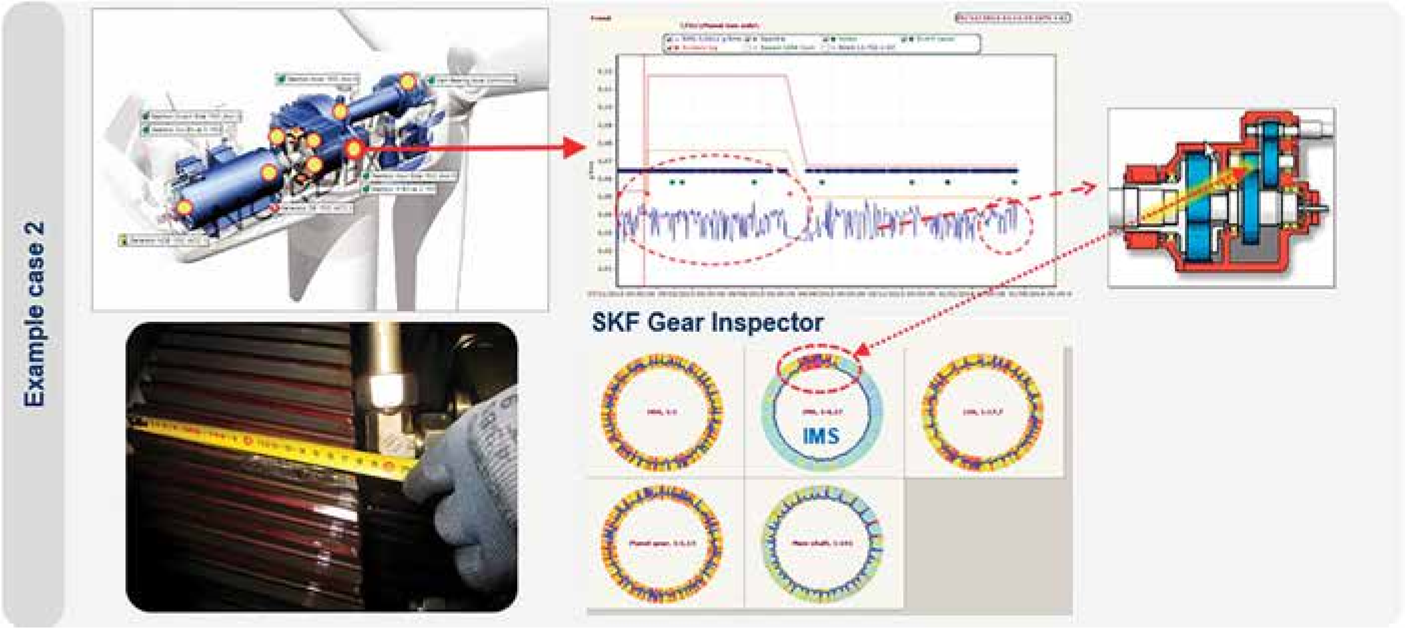
It employed the whole process of database creation, alarms assignment and issue detection based on vibration trending drift.

Spectrum analysis identified the failed component; video endoscopy picture closed the loop.

- Trend increase overall ACC (***Acceleration vibration level***) + filtered gear mesh value of planetary stage
- Spectrum analysis revealed harmonics from the planetary wheel rotation speed
- This leads to the event report; the pattern indicates where to inspect, the level indicates the level of urgency
- Boroscopy confirmed a planet wheel crack

Case 2:



In this case, the traditional techniques reached their limitations, therefore we applied a post-analysis algorithm which was developed especially for planetary gears. This demonstrated that, beyond the statistical alarms process, advanced technology is needed to increase the capabilities of condition based maintenance.

- In the initial phase, ACC alarm thresholds were set on the planetary stage, showing a slight upward trend the following month.
- Spectrum analysis showed an IMS (***Intermediate Shaft***) harmonics increase, however the absolute levels are still low.
- Gear Inspector tool, which is a display of the vibration signal spread around 360° shows an Energy Peak on the IMS wheel.
- This leads to the conclusion of an IMS wheel issue; Boroscopy confirmed a broken tooth on the pinion.

5. Outlook

The capabilities of CMS will continue to evolve as we continue to push the boundaries of the technology. One of the next steps will be to integrate further relevant sources of information such as process parameters.

Another trend is to be able to couple CMS data to another, more holistic system so as to enable better correlation. This is a major driver from the turbine manufacturers, but it also raises a cost issue. Our goal is to make the technology more affordable.

After ten years using vibration monitoring, we can improve the availability of the wind assets by one percent while at the same time reducing operating and maintenance costs by two percent.

Advanced Adiabatic Compressed Air Energy Storage (AA-CAES)

Dr. Giw Zanganeh, Managing Director
ALACAES, Lugano, Switzerland
giw.zanganeh@alacaes.com

(With the increasing infeed of wind and solar power, the issue of grid stability and storage is becoming more and more urgent. A Swiss company is developing a technology to store large amounts of energy cost effectively as compressed air and heat in mountain caverns.)

Renewable energy, especially from wind and solar, has seen massive growth in India over the last years. Already more than 18% (60 GW) of India's installed capacity is in form of renewable energy sources, of which more than 80% (47 GW) come from wind and solar. By 2027, India plans to have more than 60% of its electricity from renewable sources. Wind turbine installations in particular have seen a rapid growth worldwide and have surpassed the world's largest installed power source overall – coal plants. Global wind power generation amounted to 950 TWh in 2015, accounting for nearly 4 percent of total global power generation. In 2016, the EU-28 states generated over a quarter of their power from green sources, while globally, renewables now account for 1985 GW – over 30 percent of total power capacity.

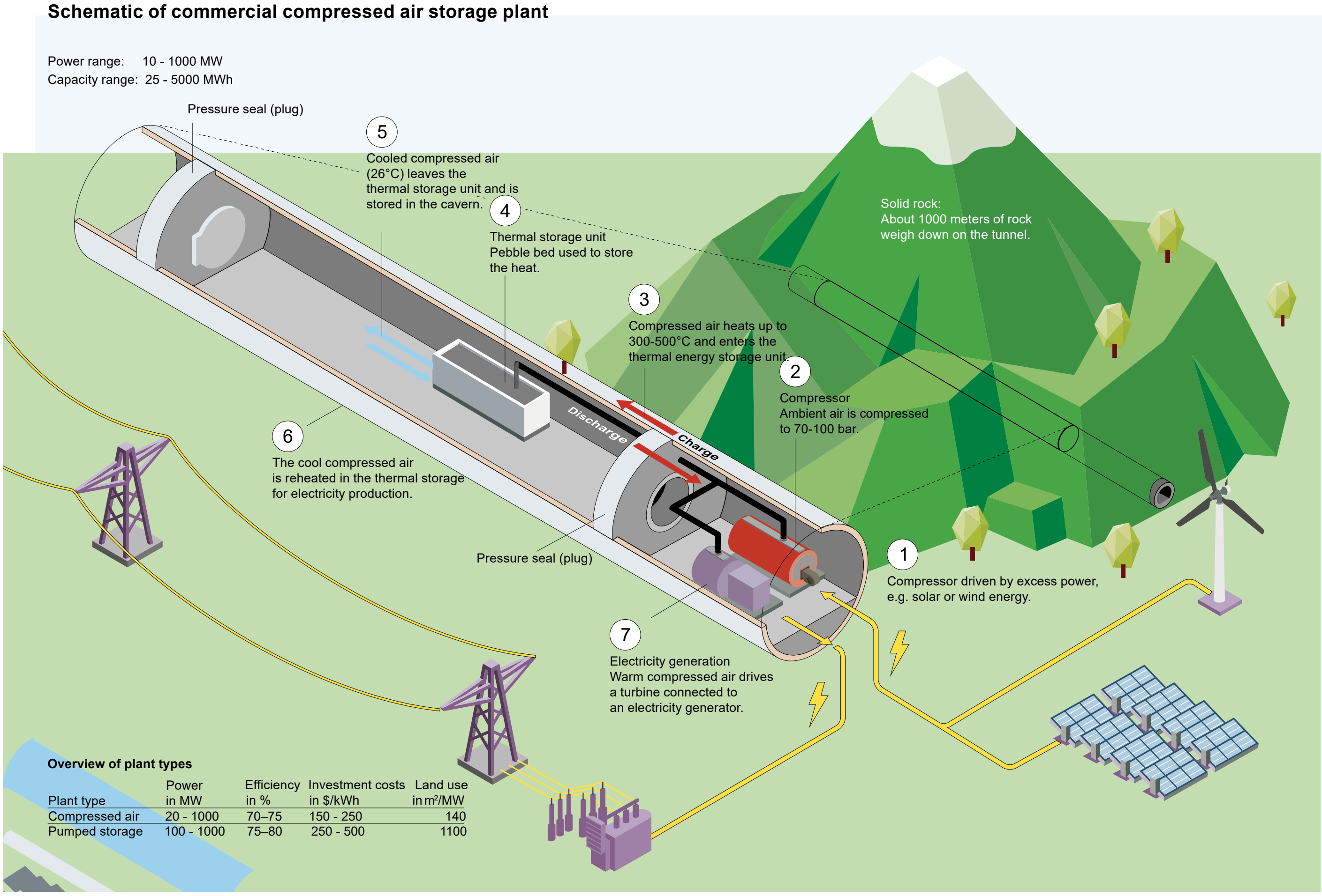


Figure 1: Scheme ALACAES

However, though good for the global climate, this trend creates headaches for grid operators. Infeed of solar and wind power fluctuates according to the weather, making it difficult to balance loads across electricity networks. This has spurred the search for efficient storage solutions – and one idea is currently being developed by a Swiss company called ALACAES.

In a nutshell, the concept of advanced adiabatic compressed air energy storage (AA-CAES) is straight forward: A compressor, driven by an electric motor powered by off-peak or renewable power, raises the air pressure in a sealed-off underground reservoir (e.g., a tunnel or cavern) up to 70-100 bar. This would cause the compressed air to heat up to more than 300-500 °C – much higher than typical tunnel or cavern construction materials can handle. The solution is to store the heat contained in the compressed air in a thermal energy storage unit, thereby reducing the temperature of the compressed air to no more than 30 °C. The thermal energy storage solution consists of a packed bed of gravel. When power is needed, the compressed air is heated in the thermal energy storage unit and expanded in a turbine connected to an electricity generator.

Compressed Air Energy Storage technology is nothing new. There are already two projects built in salt caverns – one in Germany from 1978, and a second in the United States, dating from the early 1990s. However, the existing plants discard the heat produced during compression and use gas burners to heat up the compressed air again before entering the turbine. This results in poor efficiency levels of about 40-50% as well as greenhouse gas emissions due to the gas burner. By using the thermal storage, the plant efficiency is improved to 70-75%.

The distinctive feature of the ALACAES technology is that the thermal energy storage is placed inside a much larger pressure chamber, usually a mountain or underground cavern. Therefore, the thermal storage, being in the pressure zone itself, does not have to bear any pressure. This dramatically reduces the cost and complexity of the thermal storage unit, giving this technology a major economic advantage over alternative compressed air storage technologies.

Much like pumped hydro storage this concept would allow peak loads to be met with using off-peak or renewable energy stored at an efficiency of 70 to 75 percent. That makes AA-CAES the only large-scale energy storage concept right now with the potential to compete with pumped hydro energy storage.

Since all the installations are underground, the environmental footprint of the AA-CAES technology is much smaller than pumped hydro plants, which require the creation of reservoir lakes by constructing a dam to contain the water. Due to the same reason, also the costs of the compressed air technology is 20-30% lower than pumped hydro, while having a similar life time of 40-60 years. Compared to batteries, AA-CAES is 40-60% cheaper while having a 10-20 times longer lifetime.

The world's first pilot plant of this technology was successfully built and tested in 2016 in the Swiss Alps. The pilot plant exploited a disused transportation tunnel as its pressure cavern, by constructing two 5-m thick conical concrete plugs to seal the pressure zone and an access door installed in each plug.

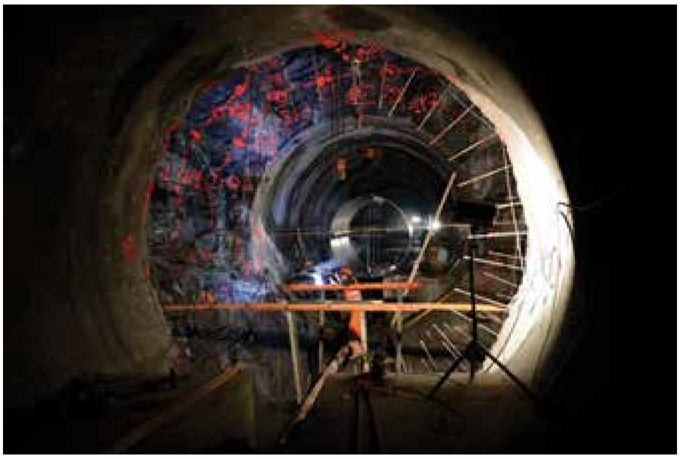


Figure 2: Plug Construction

Figure 3: Access Door

The plant was a 120 m section of the 5m-diameter tunnel and had a capacity of 1 MWh at a power rating of 600 kW. The hot pressurized air entered the pressure zone through a feeding pipe in the plug and was carried directly to the thermal energy storage.

Figure 4: Gravel of Thermal Storage

The air cooled down to ambient temperatures by flowing through the thermal storage and was subsequently stored in the empty volume tunnel section. For discharging, the process was reversed by opening the control valves, allowing the cool pressurized air to enter the TES, heat up, and leave the plant through the same pipe it entered.

Figure 5: Thermal Storage

Figure 6: Thermal Storage Construction

Figure 7: Installations

India's Largest Wind Turbine Generator Commissioned by Suzlon

Suzlon has announced the installation and commissioning of its S128 wind turbine generator at Sanganeri site in Tamil Nadu, claiming it to be the largest wind turbine generator (WTG) in India. S128 WTG is available in 2.6 MW to 2.8 MW variants and offers hub heights up to 140 metres, rotor blade 63 meters and a rotor diameter of 128 meters. The prototype of the S128 is said to be delivering close to conventional fuel competitive plant load factor (PLF).

Determination of Levellised Generic Tariff for Financial Year 2018-19

CERC tariff order dated 1st March 2018 declares that for wind (onshore and offshore) the tariff will be project specific, and not generic.

Need for the Energy Storage Systems in India

Dr. Rahul Walawalkar, Executive Director
India Energy Storage Alliance (IESA)

Why Energy Storage?

Energy storage technologies have huge potential to significantly contribute to the transformation of Indian electric grid towards a greener, resilient and reliable grid within next decade. Advanced energy storage technologies can play an important role in renewable integration, energy access, electric mobility and smart cities initiatives by the Indian Government. However, the development of advanced Energy Storage Systems (ESS) has been highly focused in select markets.

Ever since the existence of an electrical grid, grid operators have been looking for ways to safely and efficiently store energy so that can be supplied and consumed on demand. Over 170 grid scale energy storage technologies (excluding PHES) are either commercially available or are under development across different regions worldwide. The storage technologies site is distributed across a variety of systems to ensure the energy needs are met every day. This includes mechanical storage like pumped hydro storage, flywheels, compressed air and electrochemical storage such as lead acid, advanced lead acid, lithium ion chemistries, sodium-based batteries, nickel-based batteries and flow batteries. Advancements in fuel cells and traditional thermal storage are also relevant to various emerging applications.

It is also worth mentioning that energy storage is resource neutral i.e. it allows to use electricity more efficiently, regardless of the power source. Whether the energy production is from a thermal power plant or wind power plant, energy storage technologies can capture the energy and make it available when it is most needed. It also provides quality and reliable power to the end consumers.

Each country's energy storage potential is based on the combination of energy resources, infrastructure, electricity market structure, regulatory framework, population demographics, energy-demand patterns and trends, and general grid construction and condition. The efficiency of performance of these fundamental factors creates demand for new products and services, and energy storage is increasingly being sought to meet these emerging requirements.

Indian Energy Storage Market

Indian energy storage space is at interesting phase and this is the best time to enter market. Indian energy sector is becoming exciting with 50 MW+ large-scale projects announced in 2016 and 2017. Apart from these tenders, various private and government bodies are going for MW level energy storage projects in India. Other application areas like electric vehicles, charging infrastructure, microgrids, telecom tower, C&I applications, solar integration, microgrids, smart grids and smart cities will be the major catalyst for energy storage adoption in India.

The market for energy storage in the South Asia region is dominated by India. Energy storage has almost 20 different applications in India such as renewable integration, grid ancillary services, diesel minimization, micro grids for energy access and campuses as well as electric vehicles. IESA estimates the market for energy storage would grow to 100-200 GWh during 2017-22. While everybody acknowledges the importance of storage – for, without storage, there can be no smart cities, electric mobility or 24x7 power supply in remote areas – very little has been happening in India in terms of building large-scale storage capacity linked to renewable plants.

During 2017, over 100 MWh energy storage tenders were released in India. EESL has also concluded world's largest procurement of 10,000 EVs in a single tender. IESA expects solar integration, electric vehicle & charging infrastructure and commercial & industrial applications will act as catalyst for energy storage adaptations in India.

Policy makers in India have recognized the potential of energy storage that can help in Indian government to meet various policy priorities such as National Solar Mission, National Electric Mobility Mission and Mission for Energy Access. NITI Aayog as well as MNRE have been working on draft National Energy Storage Mission for past year. According to the policy makers the biggest challenge for storage is the higher upfront cost. Luckily globally the prices for storage technologies are reducing rapidly and have fallen by 90% in past 10 years. We are also confident that with local manufacturing, we can accelerate this cost reduction.


ReGen
POWERTECH
Introducing
the new ReGen make
"WD 121, 2.8 MW"
wind generator platform
with a rotor diameter of 121m.
The evolution of our highly
successful 1.5 MW and 2 MW
wind platforms, the new
WD 121 2.8 MW IEC IIIB
provides unparalleled
performance at high
efficiencies even in low and
medium wind sites.
• Advanced technology with gearless direct drive, variable speed Synchronous generator with permanent magnet excitation
• No reactive power, no dependence on grid for excitation.
• Variable speed advantage offers high efficiency at low wind speeds.
• Full 900 pitchable blades offer aerodynamic breaking.
• Generator has concentric winding with flux concentration which boosts generator performance and efficiencies.
• Maintenance free highly reliable three independent pitch system
The 2.8 MW platform offers the lowest cost of energy generation and offers the highest yield in its class earning the highest return on investment. To learn more about our new platform, please visit www.regenpowertech.com or send an enquiry to info@regenpowertech.com
ReGen Powertech Private Limited
8th Floor, KRM Plaza, North Tower, 2 Harrington Road, Chetpet
Chennai – 600 031, Tamilnadu, India
Phone: +91-44-66545566 / 429660200, Fax: +91-44-42966298 / 99.
Email : info@regenpowertech.com
www.regenpowertech.com

At the same time, there are other challenges on the policy front. The main policy intervention required is need for transparent price signal for electricity that values the peaking power and flexibility. We also need removal of barriers such as higher GST (28% for batteries vs 5% for solar) and import duties for kick starting market for advanced energy storage in India.

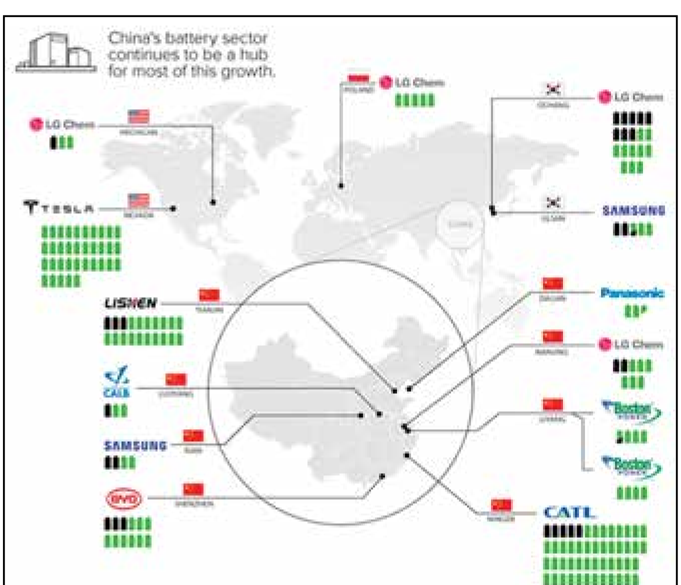
Renewable Energy and Energy Storage

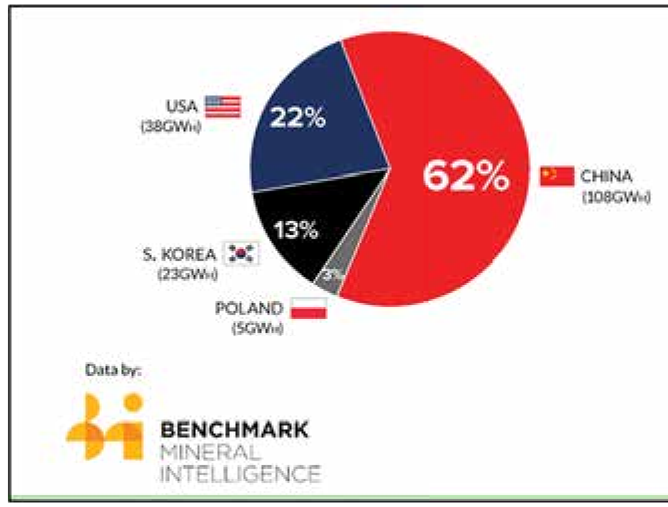
India has an ambitious plan of 175 GW renewables by 2022, including 40 GW of rooftop solar, 60 GW of grid-scale solar and 60 GW of wind. The key challenge for reaching these targets would be the ability of the grid to integrate variability associated with these renewables, as well as huge investment required for upgrading the T&D infrastructure. Energy storage can help in better integration of these renewable by providing multiple values to the system, such as optimizing T&D investments, addressing forecasting errors in wind and solar generation for more accurate scheduling, addressing local reliability issues by providing reactive power support, and also enabling end users for managing peak load and more efficient utilization of distributed renewables.

Manufacturing

According to India Energy Storage Alliance (IESA) research estimates, by 2020 there will be at least 3 companies globally with 25 GWh + annual production capacity and another 5 companies with 10+ GWh annual production capacity for Li-Ion batteries. The new projected capacity for 2020 is now over 400 GWh based on latest projections by IESA Research. India is targeting 5-10 GWh of manufacturing by 2020.

With the rapid reduction of solar and wind energy costs, Indian grid now needs solutions for renewable integration. This transition is supported by significant push for Giga factories for advanced energy storage technologies such as li-ion that is





driving down the cost of energy storage at a pace even faster than the solar PV cost reductions witnessed in past decade.

IESA's Lead Acid Battery Market Landscape Report suggests the current market size for lead acid batteries is around ₹ 27,000 crore ($4.2 billion) out of which stationary and motive applications in India takes the share of ₹ 12,650 crore. The stationary and motive application segments are likely to grow by 14 per cent CAGR until 2020 and the forecasted market will be ₹ 25,000 crore ($4 billion). In the current market scenario, inverter and UPS applications take the major share of 60 per cent of the stationary and motive battery market. Key applications which will boost the market are batteries for solar integration, electric and hybrid vehicles.

Many Indian players are also exporting lead acid batteries to countries like Sri Lanka, Philippines, Indonesia, Afghanistan and Thailand.

Manufacturing of new technology batteries is still not happening in India. Only assembly activity is witnessed. At least five major industrial groups in India are waiting for clarity in policy to foray into cell manufacturing. States such as Telangana, Andhra Pradesh, Tamil Nadu, Maharashtra and Gujarat are showing interest in attracting investments from companies to set up units in this space.

As per estimates, for cell manufacturing, 1 GWh capacity would need an investment of $300 million. Looking at the potential India has to create a 10 GWh capacity, India could attract investments to the tune of $3 billion. And as this happens, ancillary development including module development, containers, transformers, inverters could need an equal amount of investment, taking the total potential to $6 billion.

Most of the batteries currently consumed in India come from China, Korea, US, Japan and Europe. China has 60 GWh of manufacturing capacity, US has around 40 GWh, while Europe (driven by Germany) has 30 GWh. In the consumer electronics space, importing and assembling has been feasible so far for India and if tax benefits are provided by the government, indigenous manufacturing can pick up.

Currently, India has 5-6 MWh level Li-Ion assembling plants and additional 10+ conglomerates are undertaking manual assembling in small scale in India. IESA expects 3-4 Li-Ion Cell manufacturing to take place in next 2-3 years in India. There are no Li-ion cell manufactures in India but various companies like EXCIOM, ACME, Delta, Coslight and Future hi tech batteries established Li-ion assembly in India. Few Indian companies are working on other battery chemistries like sodium based battery, Zinc AR batteries. By leveraging India's vast experience in software industries there are few companies who are creating Battery Management System and Energy Management System for batteries & EVs.

Conclusion

2018 has already started witnessing the pickup of EV charging infrastructure deployment in various metro cities. Stationary energy storage market will also start seeing tracking with MW scale deployments for renewable integration as well as C&I applications. By mid-2018, India will have over 1 GWh of Li-ion battery pack manufacturing capacity. We also anticipate that in 2018 at least two Li-ion cell manufacturing plants with capacity of 500 MWh or more will start construction in India with anticipated completion for the end of 2019 or early 2020, bringing India on the global map of Giga Factories. With the introduction of various EVs (across 2W, 3W, 4W and commercial vehicles), India will start witnessing the adoption of EVs in 2018, fueled by central procurement led by EESL and various state agencies. If we start deploying energy storage projects in a systematic manner this can create a huge interest in local manufacturing and system integration capabilities.

IESA has set a vision to make India, a global hub for manufacturing of advanced energy storage systems, and we hope that with a little consistent policy direction and support in implementation, we can achieve this dream by 2022.

Policy and Regulatory Chronological Recap FY 2017:2018

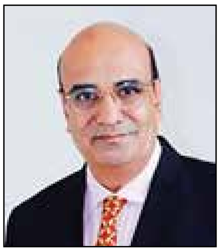
Month/Year	Entity	Policy/Regulatory Announcement	URL Link
Mar-17	CERC	CERC announced new floor and forbearance prices for Renewable Energy Certificates. These prices have become applicable from April 2017. Floor price for solar RECs have reduced from Rs 3,500 to Rs 1,000 and for Non-Solar RECs from Rs 1,500 to Rs 1,000.	http://www.cercind.gov.in/2017/orders/02 SM.pdf
Mar-17	APERC	Andhra Pradesh Electricity Regulatory Commission has recently proposed the tariff for wind energy sources which will be applicable for the projects commissioned during FY 2017-18 . Tariff without AD Benefit is Rs 4.76/kWh and with AD Benefit is Rs 4.35/kWh	http://www.aperc.gov.in/aperc1/assets/uploads/files/715b4-order op-no.-15-of-2017 wind 2017-18 310317.pdf
Mar-17	APERC	Andhra Pradesh Electricity Regulatory Commission (APERC) in its order dated 31 Mar 2017 has determined the tariff for Low Voltage (LV), High Voltage (HV) and Extra High Voltage (EHV) : Retail Sale of Electricity during 2017-18.	http://www.aperc.gov.in/aperc1/assets/uploads/files/1e111-to-2017-18 final.pdf
Mar-17	MPERC	Madhya Pradesh Electricity Regulatory Commission (MPERC) in its order dated 31st Mar 2017 has determined the tariff for Low Voltage (LV), High Voltage (HV) and Extra High Voltage (EHV) : Retail Sale of Electricity during 2017-18.	http://www.mperc.nic.in/01042017-Final-Tariff-%20Order.pdf
Mar-17	APERC	Andhra Pradesh Electricity Regulatory Commission (APERC) has released RPO percentages for the years 2017-22 vide Regulations No. 1/17 dated 31 Mar 2017	http://www.aperc.gov.in/aperc1/assets/uploads/files/22143-rppo regulation- 1.pdf
Apr-17	KERC	Karnataka Electricity Regulatory Commission in its order dated 11th April, 2017, has approved the retail supply tariff for 2017-18.	http://www.karnataka.gov.in/kerc/Court%20Orders/Tariff%202017/BESCOM%20Revised%20Retail%20Supply%20Schedule%20for%20FY18.pdf
Apr-17	KSERC	KSERC (Kerala) has recently released its retail tariff order for FY 2017-18. There has been an increase in the tariff proposed. There has been an increase in the tariff proposed for domestic consumers. The average increase has been 5.17%. for domestic consumers. The average increase has been 5.17%.	http://www.erckerala.org/userFiles/636281120645520000 Chapter%201%20to%2016 18 4 2017-final%20CM-Final%20to%20web.pdf
Apr-17	MERC	Maharashtra Electricity Regulatory Commission (MERC) Commission (MERC) has released an order for the generic tariff for renewable energy for FY 2017-18.	http://www.mercindia.org.in/pdf/Order%2058%2042/Order-33%20of%202017-28042017.pdf
May-17	TSERC	Telangana State Electricity Regulatory Commission (TSERC) has determined the transmission tariff for the FY 2017-18 and FY 2018-19 in its order dated 1/05/2017.	http://www.tserc.gov.in/file upload/uploads/Tariff%20Orders/Current%20Year%20Orders/Transmission%20Tariff%20Order%203rd%20CP%20BP.pdf
Jun-17	Niti Ayog	Released : 2017 Draft National Energy Policy (NEP) , drafted by the NITI Aayog, takes the baton forward from the 2006 Integrated Energy Policy in setting the trajectory of growth for the energy sector. The recommendations are based on India's energy ambitions by the year 2040	http://www.niti.gov.in/writereaddata/files/document publication/NEP-ID 27.06.2017 0.pdf
Jun-17	CEA	The 19th electric power survey (EPS) report is released by the Central Electricity Authority (CEA). Electrical energy requirement is expected to grow by 37% in five years, and the country needs 1,566 billion units (BUs) of energy in FY22, the report states.	http://www.cea.nic.in/reports/others/planning/pslf/summary 19th eps.pdf
Jun-17	TANGEDCO	TANGEDCO issues RfS document to procure wind power from these Projects through a Long Term Power Purchase Agreement up to a capacity of 500 MW considering a fixed tariff of Rs.3.46 as an upper limit.	

Jul-17	MPERC	RPO Madhya Pradesh Electricity Regulatory Commission (MPERC) has determined the RPO percentages which are to be followed by the obligated entities of Madhya Pradesh .	http://www.mperc.nic.in/010717-6th-Amend-Co-gen-eng.pdf
Jul-17	RERC	Rajasthan Electricity Regulatory Commission (RERC) has determined the generic tariff for sale of wind power for the FY 2017-18.	http://rerc.rajasthan.gov.in/TariffOrders/Order268.pdf
Jul-17	MPERC	Madhya Pradesh Electricity Regulatory Commission (MPERC) has released the proposed seventh amendment for Cogeneration and generation of electricity from RE sources of energy.	http://www.mperc.nic.in/280717-7th-Amend-Co-Generation-Eng.pdf
Aug-17	APERC	APERC released its final regulations on the forecasting, scheduling and deviation settlement mechanismof solar and wind projects in Andhra Pradesh. (effective from Aug 21st, 2017)	http://www.aperc.gov.in/aperc1/assets/uploads/files/6be64-forecast-regulation.pdf
Aug-17	TNERC	Tamil Nadu Electricity Regulatory Commission (TNERC) has determined the distribution and transmission tariff for FY 2017-18.	http://www.tnerc.gov.in/orders/Tariff%20Order%202009/2017/TariffOrder/TANGEDCO-11-08-2017.pdf http://www.tnerc.gov.in/orders/Tariff%20Order%202009/2017/TariffOrder/TANTRANSCOORDER-11-08-2017.pdf
Aug-17	GERC	Gujarat Electricity Regulatory Commission (GERC) has released draft regulations on procurement of Energy from RE sources	http://www.gercin.org/uploaded/document/909d4f00-645e-402a-9fc0-583e09b82306.pdf
Aug-17	TANGEDCO	Tamil Nadu Generation and Distribution Company held a 500 MW Wind Auction where the winning price was Rs 3.42 per kWh. The projects were awarded to ReGen Powertech (200 MW), Leap Green Energy (250 MW) and NLC India (50 MW).	
Aug-17	MoP	MoP releases a consultation paper on the issues faced in operationalisation of Open Access	https://powermin.nic.in/sites/default/files/webform/notices/Seeking_Comments_on_Consultation_paper_on_issues_pertaining_to_Open_Access.pdf
Sep-17	RERC	RERC has released final Forecasting, Scheduling and DSM regulation for wind and solar forecasting and scheduling	http://rerc.rajasthan.gov.in/Orders/Order418.pdf
Sep-17	KERC	Karnataka Electricity Regulatory Commission (KERC) has determined the generic levelised tariff for FY 2017-18 for wind power projects@Rs 3.74/kWh	http://www.karnataka.gov.in/kerc/Downloads/Tariff%202017/Dated%2004.09.2017-Wind%20Tariff%20Order-DT_MA.pdf
Oct-17	SECI	SECI announces the five winners of the Tranche II (1000MW) ISTS wind power e Reverse auction and the lowest price discovered was INR 2.64/kWh	file:///C:/Users/Nitin%20Raikar/Desktop/IWTMA/Data/SECI%20Auctions/SECI%20Tranche%202%20Wind%201000%20MW%20result%20website%20upload(2).pdf
Nov-17	MNRE	MNRE accords sanction for the scheme of setting up of 2000 MW ISTS connected wind power projects with issuance of subsequent guidelines	http://mnre.gov.in/file-manager/grid-wind/Scheme-for-setting-2000MW-ISTC-connected-Wind-Power-Projects.pdf

Nov-17	SECI	SECI issues RfS for setting up of 2000 MW ISTS-connected Wind Power Projects (Tranche-III)	http://www.seci.co.in/web-data/docs/tenders/RfS_Wind%20Power%20Developers_2000MW%20ISTS%20Connected-Tranche-III%20-Final.pdf
Dec-17	MSEDCL	MSEDCL, Maharashtra releases RfS for procurement of power on long term basis through competitive bidding process followed by reverse e auction from 500 MW Grid connected Wind Power Projects.	https://www.mahadiscom.in/supplier/downloads/RfS500MWWind_22122017.pdf
Dec-17	GUVNL	New Low Wind Tariff of ₹2.43/kWh Recorded in GUVNL's 500 MW Auction	http://www.guvnl.com/DownloadFiles/File/Wind%20Tender%20-%20Result%20of%20e-RA.pdf
Dec-17	MoP	MoP releases guidelines for tariff based Competitive Bidding process for procurement of power from Grid connected Wind Power Projects	http://mnre.gov.in/file-manager/UserFiles/guideline-wind.pdf
Jan-18	MNRE	MNRE vide letter 8/7/2017 dated 12 Jan 2018 issues clarification to States/UT that they can consider procuring power from Solar and wind projects of less than the defined threshhold prescribed (25 MW for wind and 5 MW for Solar) in the Competitive Bidding Guidelines through Feed In Tariff (FiT) to be determined by concerned SERCs.	https://drive.google.com/open?id=1ElamUhnefngqakW6h_s1GTBw7RfnULBD
Feb-18	SECI	SECI issues RfS for setting up of 2000 MW ISTS-connected Wind Power Projects (Tranche-IV)	http://seci.co.in/web-data/docs/RfS_Wind%20Power%20Developers_2000%20MW%20ISTS%20Connected-Tranche-IV%20final%20upload.pdf
Feb-18	SECI	Solar Energy Corporation of India (SECI) has successfully auctioned 2 GW of Inter-State Transmission system (ISTS)-connected wind projects under Tranche III	
Feb-18	MoP	The Ministry of Power releases order which provides extension on the waiver of intra-state transmission charges and losses for transmission of electricity generated from solar and wind sources upto 31st March 2022.	https://powermin.nic.in/sites/default/files/webform/notices/Waiver_of_inter_state_transmission_of_the_electricity.pdf
Feb-18	KERC	KERC vide order dated 08 Feb 2018 makes it mandatory for DISCOMs to procure Wind power only through the process of Competitive Bidding. This is in accordance with the guidelines dated 08 Dec 2017 by MoP/GoI	http://www.karnataka.gov.in/kerc/Court%20Orders/OO%202017/Order%20Dated-08.02.2018%20-%20Mandatory%20procurement%20of%20wind%20power%20through%20Competitive%20Bidding.pdf
Mar-18	MNRE	MNRE issued the course of action as part of an order that pertains to the compliance of WTG models to the technical standards of the Central Electricity Authority (CEA) for grid connectivity (Low voltage ride through (LVRT) certification)	https://drive.google.com/open?id=1ElamUhnefngqakW6h_s1GTBw7RfnULBD
Mar-18	MSEDCL	Winning Bids of 2.85-2.87/kWh Quoted in MSEDCL's 500 MW Wind Auction	https://mercomindia.com/msedcl-tenders-500-mw-wind-projects-meet-non-solar-rpo/
Mar-18	KERC	The Karnataka Electricity Regulatory Commission (KERC) has reduced the banking period of renewable energy projects from one year to six months. Banking period for wind : Jan to Junn and w.e.f 01 Jul 2018.	https://mercomindia.com/karnataka-banking-period-solar-renewable/

Researched & Compiled by Nitin Raikar - Associate Director (Communications) - Indian Wind Turbine Manufacturers Association (IWTMA)

Type Certification of Wind turbines including Central Electricity Authority/Low Voltage Ride Through (LVRT)



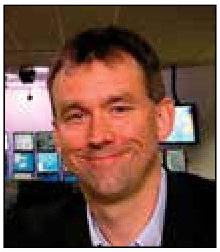
Dr. Sanjiv Kawishwar, Senior Vice President
ReGen Powertech Private Limited

- Grid stability and supply security are two major elements of the power supply.
- In order to avoid failure risk of the supply, the power generating plants should have better monitoring, control capabilities and protection system.
- Grid protection systems were implemented by the conventional power plant as major share of power were produced by them.
- Wind energy contribution in overall power generation is increasing day by day in India, therefore 'Grid Codes' are now getting enhanced to include systems like LVRT.
- Grid code requires control of electrical characteristics for the generation of power with Low Voltage Ride Through (LVRT)/Fault Ride Through (FRT) capability of generating power plant.
- LVRT has become an important feature of the wind turbine control system.
- **The LVRT term in context of wind energy generation** - Wind generating stations shall remain connected to the grid when voltage at the interconnection point on any or all phases dips.
- LVRT mechanism boosts the terminal voltage at the point of connection of the wind turbine when there is a fault at the remote location to provide transient stability support. LVRT is the capability of the electrical device to operate through periods of lower grid voltage.

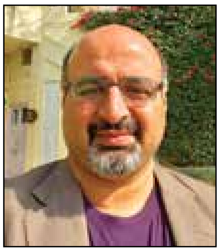
Certification Perspective

- Either Type Certificate of wind turbines should include compliance to CEA Technical standard for connectivity to grid (No. 12/X/STD(CONN)/GM/CEA dated 30th September 2013) under Prototype Testing certificate (SOC) or in a separate Conformity Statement (CoC).
- Grid connected wind turbines in India are certified according to GL 1999/GL2003/ IEC-WT-01/TAPS 2000/ GL 2010/IEC 61400-22 type certification schemes.
- Power Quality of **GL 2010** compliant wind turbine model is measured as per chapter 10.4 of GL guidelines according to clause 6.1 to 6.4 of IEC 61400-21 that covers 'Flickers' and 'Harmonics'. LVRT testing (6.5 to 6.9 clause of IEC 61400-21) is optional.
- Complete 'Power Quality' measurements for **IEC 61400-22** compliant wind turbine model are optional. Accordingly, measurement campaign should be planned.
- GL 1999/GL2003/IEC-WT-01/TAPS 2000 certified wind turbines will require upgradation to GL 2010/IEC 61400-22/IECRE OD-501 to achieve CEA compliance.
- Upgradation of wind turbine to any of the latest schemes in vogue will require change in many load bearing components like Drives, Bearings, Gearbox, etc.
- Type Certificate, Statement of Compliance (SoC) or Conformity Statement (CS):
  - A. CEA notification compliance statement to be included in Prototype Testing certificate.
  - B. To include technical compliance evaluation details in electrical characteristics report.
  - C. CEA/LVRT compliance statement to be included in Final Evaluation Report also.
- Type certification Body must have accreditation for CEA Technical standard for connectivity to grid (No. 12/X/ STD(CONN)/GM/CEA).
- Latest notification (dated 01.03.2018) from MNRE states that 'Self-Certification for the wind turbine models that are yet to be tested for LVRT compliance according to aforementioned CEA technical standards is acceptable for inclusion in a separate self certification table in RLMM. Self certified wind turbine model will remain in the list till 31.03.2019 and disconnected from the grid if compliance certificate (SOC/CS) is not produced by the date.

Mitigating Risk with Probabilistic Forecasting



Todd Crawford
Senior Meteorological Scientist



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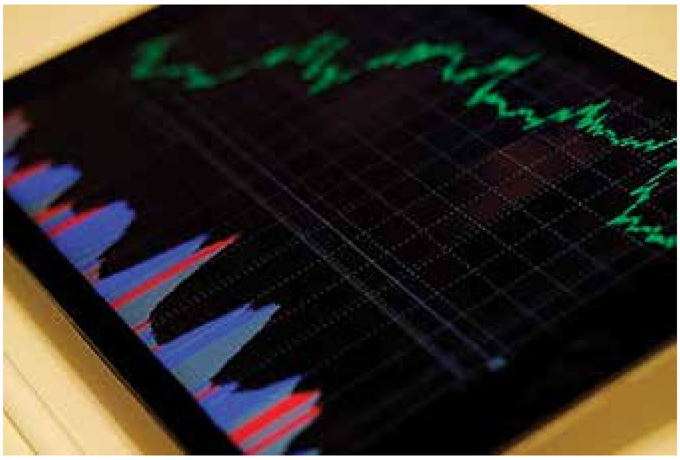
The Weather Company, an IBM Business



Throughout history, meteorologists have worked to improve weather forecasting technology. In the last 20 years, that work has increased with the help of data scientists, cloud computing, machine learning and advanced analytics to create today's superior weather forecasting technology. Providing clients and consumers with these forecasts is incredibly valuable, but imagine if that forecast also contained useful information on the full range of forecast possibilities as well.

Some forecasts are more difficult and uncertain than others, and only the use of probabilistic forecast information can adequately convey the complexities of a given situation.

Leaders in weather data and distribution are now providing probabilistic forecast information to its clients, via API or new products, to help them simplify business decisions with probabilistic forecasting for the energy industry.

The Full Range of Possible Outcomes

Probabilistic forecast information offers you the ability to capture a range of possibilities for any given weather forecast while highlighting extreme risks. Instead of simply displaying the output of one weather model ensemble, such as the ECMWF; it combines all available global and regional models. Rather than only having access to a predicted temperature, you get access to the odds of each possible outcome, allowing you to factor risk tolerance into your decision-making process.

If the forecast predicts a temperature drop over the next week with a vast range of possibilities, that forecast carries a higher risk. The probabilistic model allows you to step back and look at the big picture – to go slow and not throw a huge market position down. Similarly, if the forecast shows that a cold trend with a small range, there's a lower risk and you can increase the size of your bet.

For example, the table shows how clients can use a probabilistic product to quickly visualize forecast uncertainty for a region and variable (temperature or precipitation). In the example below, the user can easily see higher uncertainty across Serbia on Monday, 26 March, relative to the surrounding days, followed by increased uncertainty later in the forecast period as is usually the case.

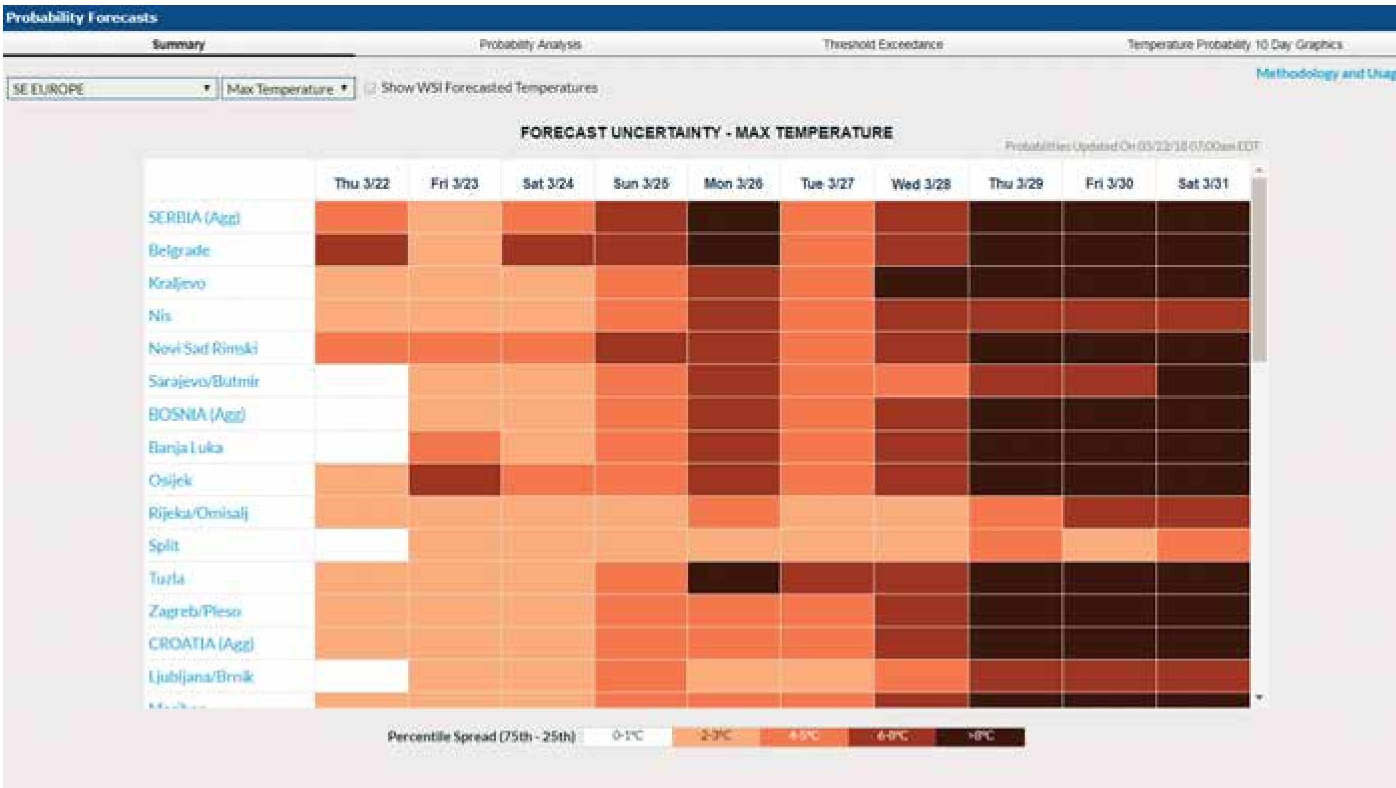
Another visualization is shown below; exceedance thresholds for various temperatures are provided for a given location (Central Park in New York City, in this case) – It's easy to see the increasing probabilities for warmer temperatures with time (reds and oranges). The graph at the top of page also allows the user to discern the direction of forecast risk. In this case, the forecast for 30 March is 12 degrees, but the data suggests a 71% chance that it ends up warmer than that.

Superior singular forecasts are providing energy traders and demand forecasters with additional insights on the range of possibilities.

Today, current forecasts show you only a single, anticipated "least error forecast," or the most likely forecast based on what an array of different models are showing. With probabilistic forecasting, we can fill the gap about what we know and don't know in a transparent way. It offers what more models show to give clients a decision-specific probability of multiple weather outcomes and help them make a decision. In short, probabilistic forecasting helps businesses embrace uncertainty.

The Future of Wind Power Forecasting

Forecasting wind power output for a region, or even an individual wind turbine, is a particularly good use case for probabilistic forecasting capabilities. Since there is not a linear relationship between hub-height wind speed and wind power output, even small weather forecasting errors can result in large wind power forecasting errors. The risk in relying on a single forecast, then, is particularly amplified in this case. Instead, if you input 100 equally likely forecast wind speeds into a wind power model, you can get a realistic forecast distribution of wind generation scenarios that will allow for a more robust estimate of all possible outcomes, which will allow the load dispatch centers to better prepare for the sort of "tail events" that can catch a business off guard.



Geo-tagging/ Online Registry of Wind Turbines Installed in India

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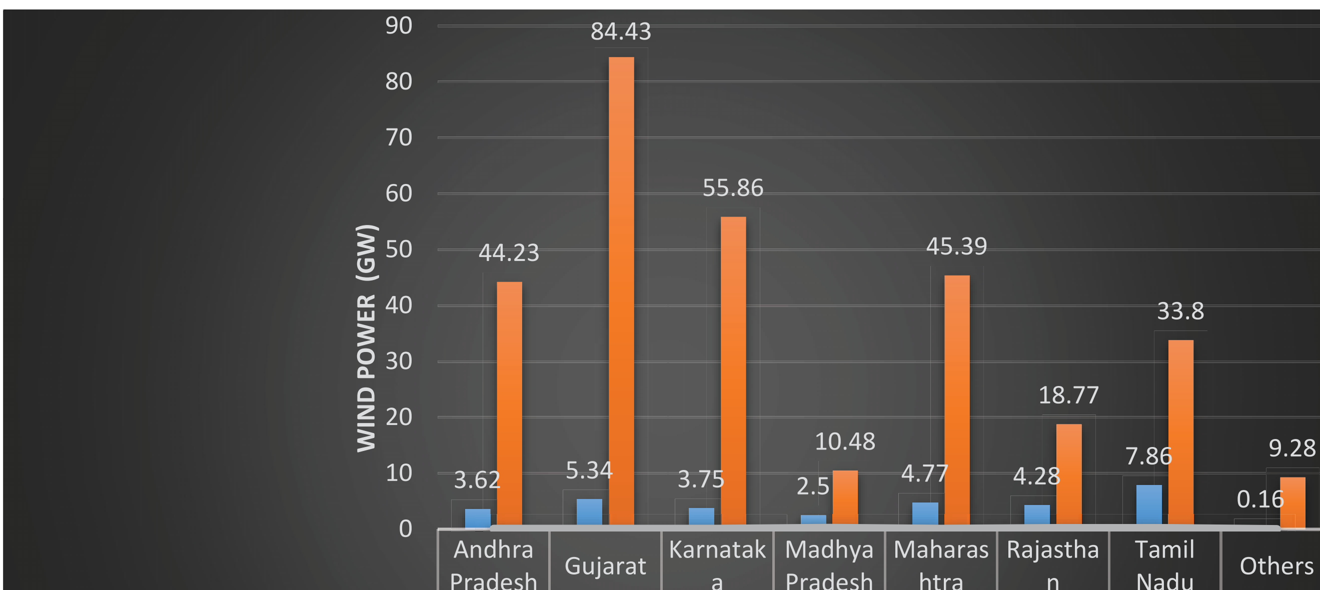
1. Introduction

India has a lot of untapped wind power potential, and a target to achieve 60000 MW by 2022. As on date, the wind turbine installed capacity in India stands at approx. 33000 MW[1]. The present wind power installed capacity in the country is 55% of the total renewable installed power generation capacity. The contribution of wind energy in the total renewable generation during 2014-15, 2015-16 and 2016-17 was 55%, 50% and 56% respectively. The Figure 1 below shows the state wise installed capacity as on 31.03.17 and the installable wind potential at 100m agl.



	Andhra Pradesh	Gujarat	Karnataka	Madhya Pradesh	Maharashtra	Rajasthan	Tamil Nadu	Others
Wind Capacity - as on 31.03.2017 GW	3.62	5.34	3.75	2.5	4.77	4.28	7.86	0.16
Wind Potential @100 m GW	44.23	84.43	55.86	10.48	45.39	18.77	33.8	9.28
Wind Capacity achieved %	8.18%	6.33%	6.72%	23.84%	10.51%	22.81%	23.26%	1.68%

Source: MNRE

Figure 1: State Wise Installed Capacity of Wind Turbines

The wind turbine installations in India are mainly spread across the states of Tamil Nadu, Andhra Pradesh, Telangana, Karnataka, Gujarat, Rajasthan, Maharashtra, Madhya Pradesh and Kerala. It is estimated that 32,246[2] no. of wind turbines have been installed in India from 1989-90 to 2016-17, which is a vast asset base. However, there is no centralized system of maintaining this vast database exists as on date and there is a dire need in the country to formulate the Online Registry / Geo-tagging mechanism of wind turbines for the benefit of the wind turbine stake holders.

2. Background

Ministry of New and Renewable Energy (MNRE) vide their Guidelines for Development of Onshore Wind Power Projects issued on 22.10.2015 has also desired that the centralized system shall be created to develop a geo-tagged data base / online registry of wind turbines installed and proposed to be installed across the country with the support of central and state agencies. For the purpose, NIWE is working to devise the methodology for the static data collection.

The objective of the present exercise is;

i. To create a registry of information of wind turbine installations viz., location of the wind turbine, type of wind turbine, its rating along with critical technical information, power generation details, etc.

ii. To map the spatial / geographical distribution of the installed wind turbines vis-à-vis the potential areas

iii. To effectively realize the untapped wind potential and providing road map to the wind energy related targets of Government.

iv. To keep track of condition and health monitoring of wind farms

v. To create mechanism for repowering of the aged wind farms

vi. To create better framework for wind power forecasting- Forecasting of wind power based on clustering methods helps achieve better accuracies and reduce computational costs compared to power forecast methods based on one representative wind turbine for the entire wind farm.

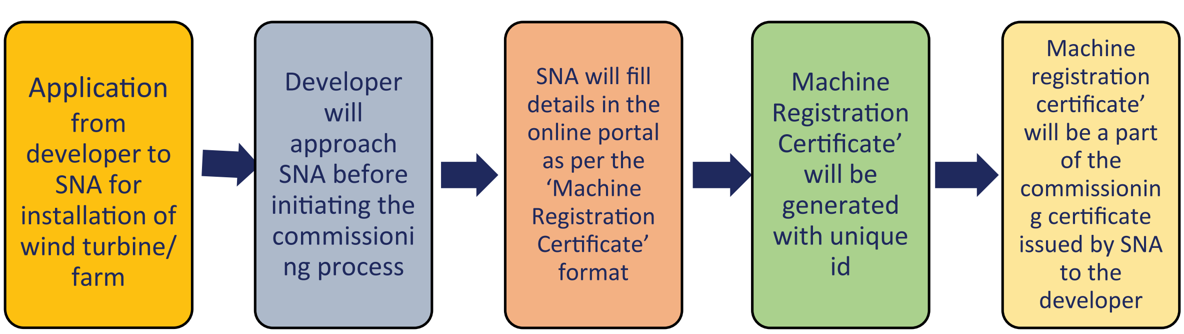
vii. On the later stage, the details will be useful for effective grid planning and management.

3. Framework for Online Registry

Under the project, a framework to enable data collection from all the relevant stakeholders and consolidation at a single point (at NIWE) is proposed to be put in place. A 'unique ID' mechanism with relevant secondary information stored at the back-end, has been designed and the same will be seamlessly integrated with all the existing wind turbines. In the future, the unique Id will be integrated during the proposed wind turbine's commissioning process itself and reflected in the Power Purchase Agreements (PPAs). This is considered as necessary for the successful implementation of the project.

Under the project, NIWE will develop an online portal for managing the registration process of the wind turbines and for generating the unique identification number. In the case of existing wind turbines, the wind turbine details will be collated from State Nodal Agencies (SNAs) / State Utilities and NIWE will carry out the registration process and develop the data bank. In this regard, NIWE has already started the process and data collection is underway from various SNAs and stakeholders.

For the future projects, the developer shall approach State Nodal Agency (SNA) / state utility at least one month prior to scheduled commissioning process for allotment of 'unique id' and the SNA shall complete the registration process in the online portal by filling details as per the 'Machine Registration Certificate' format shown in Figure 2. The 'Machine Registration Certificate' with the unique id will be a part of the commissioning certificate issued by the SNA to the project developer. The process flow for future wind projects is proposed to be as follows:



4. Development of Unique Identification Code

The 'Unique Identification Code' for the development of Centralized Registry has been devised thoughtfully, avoiding chances of over-run. The Unique Identification Code will be an alphanumeric code coined with' key attributes' of the wind power project and will remain a perpetual one. The id would be a generic one and is designed such that it does not reveal any information on the installations of a wind turbine of particular rating or manufacturer. Proposed format of Unique Identification Code will be as follows,

TN01AAZAA10

(State Code - Year of commissioning - Global model code - Regional Code - Unique Turbine No)

The following key attributes will form the unique id:

4.1 **State Code:** Since the machine registration will be handled at the 'state level', a state code will be used. This will give information on the installations taking place in a state. For example: 'Tamil Nadu' will be indicated by 'TN'.

4.2 **Year Code:** The year code will give the 'year of commissioning'. For example installations taking place in '2001' will be indicated as '01'.

4.3 **Global Model Code:** The Global Model Code has been formulated by dividing the land area of the country into 0.25^o x 0.25^o grid cells, totaling 5108 grid cells, to match with NCMRWF (National Centre for Medium Range Weather Forecast) Forecasting Global Model grid resolution. A three alphabet combination (starting from **AAA** to **HOL**) is designed to represent the 5108 grid cells of the Global Model code. The 0.25^o x0.25^o discretized map is shown in Figure 2.

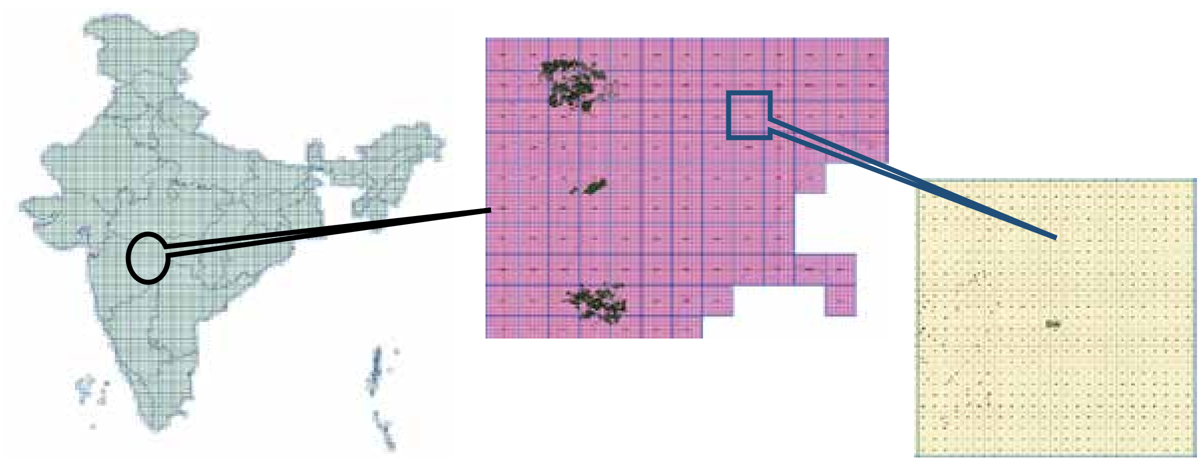


Figure 2: Global Grid Code Discretization for Unique Identification of Wind Turbine

4.4 **Regional Code:** The 0.25^o x 0.25^o grid cells have been further divided into 0.01^o x 0.01^o blocks to represent Regional code. The discretization to the level of 0.01^o x 0.01^o blocks is proposed to enhance the flexibility of creating a domain of any size, which will be useful for forecasting and resource mapping applications. A two alphabet combination (starting from **AA** to **YA**) was designed to represent the total 625 blocks of 0.01^o x 0.01^o size located within a 0.25^o x0.25^o grid cell. The Reginal Code discretization can be further represented as Figure 3.

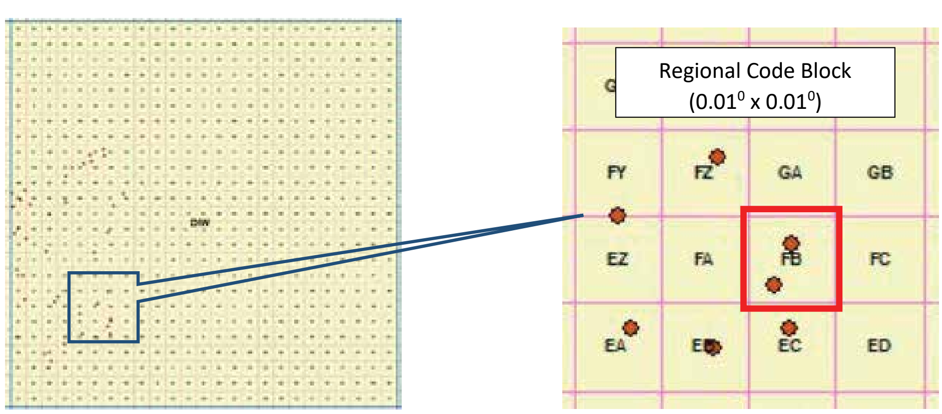


Figure 3: Regional Code Discretization

4.5 **Turbine Number:** Each turbine within the block of 0.01° x0.01° will be assigned a unique number. Considering older machines, probably each block of 0.01° x 0.01° may contain to the maximum of about 30 wind turbines and in order to represent those number of machines, 2 numerical digit unique turbine number has been proposed. The number sequence will roll regional code wise.

6. Conclusion

Development of the centralized online registry of wind turbines with geo-tagged secondary information is expected to be much useful for orderly and systematic development of the wind sector in the country. With the inclusion of dynamic data such as generation details into the registry, the archive is expected to open up multi-fold applications and will help identifying newer sites to the respective state nodal agencies thereby fostering the growth of wind turbines which in turn will help in expediting to meet the target of 60 GW by 2022.

References

[1] Accessed from www.mnre.gov.in

[2] Indian Wind Power Directory 2017, CECL

Annexure I

Machine Registration Certificate

Turbine Location Village District State Latitude Longitude	
Date of Commissioning	
Turbine Details Make Model Rating Hub Height Rotor Diameter	
HTSC / Service Connection No.	
Owner Name	
Mode of Sale of Power - (Captive / PPA / Third Party Sale	
Substation Details Name Voltage level Feeder Name Feeder Voltage	

Filled by: ____________ Checked by: ____________

Issuing authority

Indian Wind Industry Analytical Report - FY 2017-18

Nitin V Raikar
Indian Wind Turbine Manufacturers Association (IWTMA)
(nitinraikar@indianwindpower.com)

Key Pointers

Installed Capacity

- FY 2018E witnessed a substantial drop in installation volumes primarily due to the transition phase from the FiT regime to the auction based regime
- Commissioned capacity addition of 1.85 GW in FY 2017-18 as against 5.5 GW in FY 2016-17
- This represents a dip of close to 66% for the corresponding period in last fiscal
- This capacity addition translates to an investment of ~ 1.85 billion USD
- Cumulative Wind power capacity in India surpasses 34 GW mark and stood at ~34.14 GW as on 31st March 2018
- Cumulative Wind capacity constituted close to ~50% of India's total Grid Interactive Renewable Energy capacity
- Cumulative Wind capacity constituted ~9.8% of India's total installed power capacity from all energy sources

Environmental Benefits Quantified

- Cumulative Grid Interactive wind power installations would translate to (on per annum basis)
  - Emission offset of ~73 million tonnes
  - Coal savings of ~55 million tonnes
  - Sulphur Dioxide emission offset of ~ 0.60 million tonnes
  - Tentatively power ~18.5 million number of Households
  - Equivalent cars taken off the road/year ~12 million
  - Equivalent Number of Trees planted per annum ~ 6062 million trees

Key Pointers – States

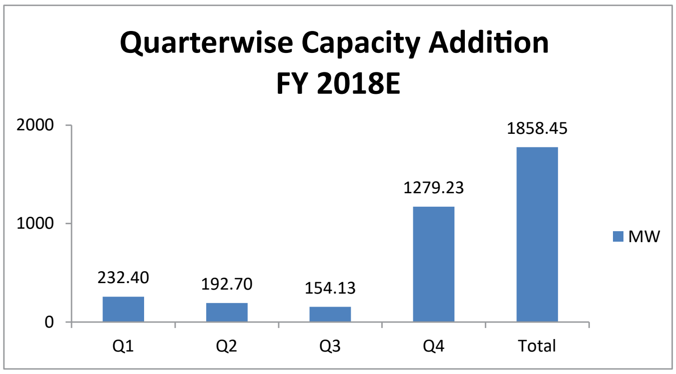
- Karnataka leads in capacity addition by commissioning 856.9 MW followed by AP (348.10 MW), Tamilnadu (324.35MW), Gujarat (272.80MW), Madhya Pradesh (22.10MW), Rajasthan (16 MW), Maharashtra (12.60MW), Kerala (1.0MW)
- Installations in all the 8 windy states

State wise capacity addition for FY 2017-18 with comparison to FY 2016-17

State	FY 2016-17 (MW)	FY 2017-18 (MW)	Growth/ De-growth %
Andhra Pradesh	2179.45	348.10	~84%
Gujarat	1391.65	272.80	~80%
Karnataka	905.55	856.90	~5%
Madhya Pradesh	356.70	22.10	~94%
Rajasthan	287.70	16.00	~94%
Tamilnadu	256.13	328.85	~27%
Maharashtra	93.30	12.60	~86%
Kerala	0.00	1.00	
Total	5509.58	1858.45	~66%

Key Pointers – Original Equipment Manufacturers (OEM)

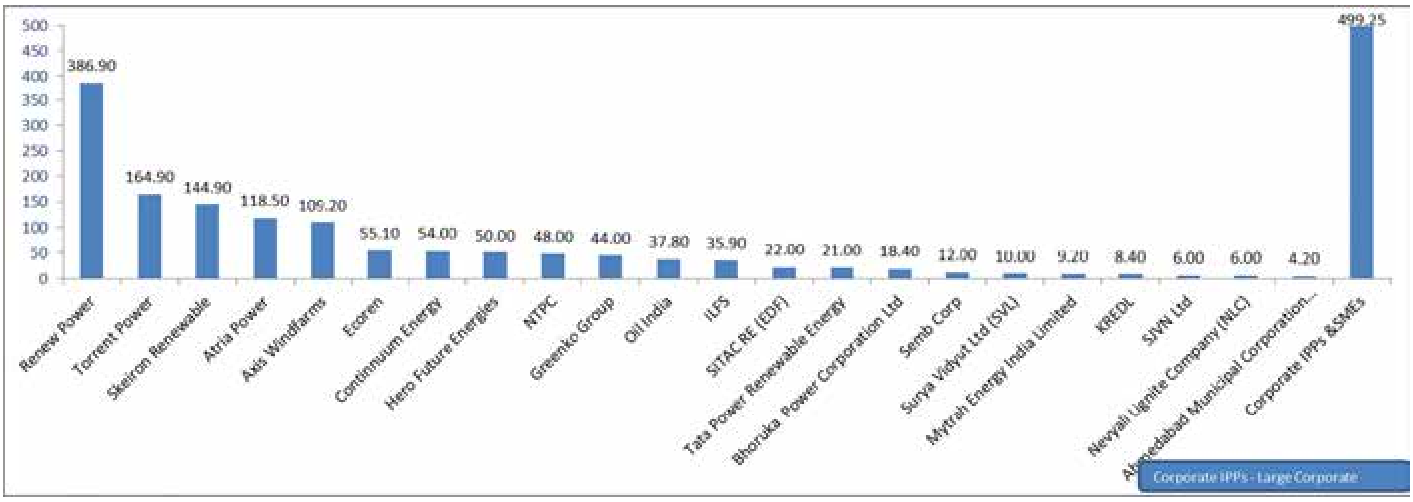
- Total No. of Original Equipment Manufacturers (OEMs)who added capacity: 14
- The top 5 OEMs (who added capacity ~100 MW and above) constituted ~92% of the total installed capacity

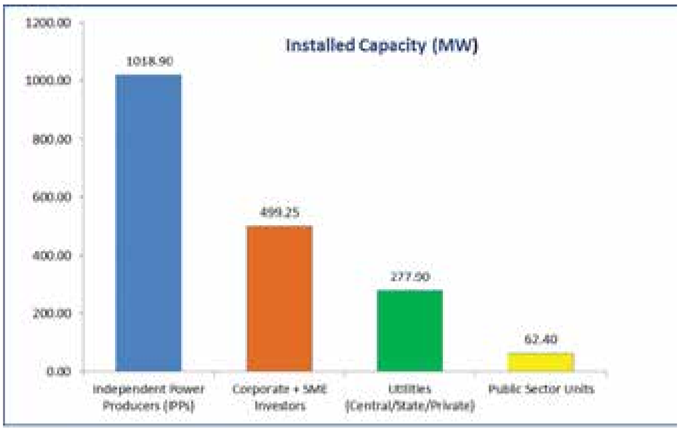


- Suzlon Energy Limited
- Siemens Gamesa Renewable Pvt Limited
- Vestas Wind Technology India Private Limited
- Inox Wind Limited
- GE India Industrial Pvt Limited

➢ Top OEMs who have a cumulative installation base exceeding 1000 MW or 1GW in India –
- Suzlon Energy Limited - ~11.92 GW
- Gamesa Renewable Pvt Limited ~ 5.3 GW
- Wind World (India) Limited ~4.9 GW
- Vestas Wind ~2.3 GW (excluding Vestas turbines of RRB Energy)
- Regen Powertech Pvt Limited ~2.3 GW
- Inox Wind Limited ~2.3 GW

Key Investors : FY 2018E Installation chart & Segmentation





Key Pointers – Product/Technology/Milestones

➢ A total of 995 WTGs of different make and type were installed and commissioned

➢ Average turbine size decreased to 1.87 MW from 1.93 MW corresponding to the preceding FY 2016-17

➢ Siemens Gamesa develops India's first large commercial hybrid wind-solar project - 28.8-MW solar facility connected to an existing 50-MW wind farm

➢ Suzlon Energy Limited successfully proto commissions its new product – S128 with a Rated Capacity of 2.1 MW & Rotor Dia of 128 meters

➢ Vestas debut commissions its V110 Rated Capacity 2.2 MW WPP in this fiscal in Karnataka, India

➢ Gamesa surpasses 5GW of installations in India

Key Pointers – Product Size & Range

Product Class Segmentation for FY 2017-18						
Product Size (Range)*		No of WTGs	% of total WTGs	MW	% of total MW
"Mainstream"	< 1500 - 3000 kW	864	86.83%	1767.00	95.08%
"Megawatt"	< 751 - 1499 kW	75	7.54%	57.20	3.08%
"Small WTGs"	< 750 kW	56	5.63%	34.25	1.84%
Total		995		1858.45	
Average Rated Capacity (MW)			1.87		

*Methodology sourced from web sources

Classification by Drive train topology

Drive Train Topology	% of total MW installed	% of total Nos. of WTGs installed
Geared Drive Train	94.79%	90.65%
Direct Drive Train	5.21%	9.35%
Geared Drive train topology continues to dominate		

Disclaimer

➢ The information contained herein has been compiled and collated from grassroots MI sources but its accuracy and completeness are not warranted, nor are the opinions or analysis which are based upon it

➢ However the data is fairly accurate and is based on extensive reconciliation with relevant industry stakeholders

➢ The statistical data if presented or published by the relevant government agencies in due course of time, shall prevail in all eventualities

➢ "E&OE Regretted"

Proactive Risk Assessments – Keeping Organizations Informed on Engineering, Technological and Operational Changes

Abhay Laxmanrao Waghmare, Sr. Manager, Reliability, LM Wind Power Technologies Pvt. Ltd.

Introduction

With an ever increasing competitiveness in renewable energy space, there is a need to reduce the Levelized Cost of Energy (LCOE), there exists a need to look for possible changes in terms of design, operations, manufacturing, materials, and supply chain etc. to keep a check on cost of the turbine blade. Thanks to the fact that rotor blades alone represent approximately 15-20% of the investment in a wind turbine.

To support the cost reductions, innovations are highly encouraged to contribute towards lower cost or higher AEP. With innovations pouring in at a decent pace in ways like taking out costs of the blades, reaching new geographies to start a manufacturing plants, industrializing the technologies, reducing the environmental impact, exploring new materials, new ways to transport etc. are good enough to shake the dynamics, blades have been made in industry. Supplement this fact with reducing warranty cost reserves, potential extended warranties on offer, reduced time for innovation and NPD. With all fluidic priorities around, there exists financial risk to the organization. This article refers to such scenarios, where methods have been discovered and applied on various change types to estimate the financial risk of implementing the change based on engineering and test data.

The inspiration to strengthen the proactive risk assessments is heavily on the fact of assessing impact of changes to address cost reduction and warranty improvements. The primary objective is hence to avoid risk and to have a contingency plan in place to handle unavoidable risks in a controlled and effective manner. All this is done with structured procedures to assess/ estimate the warranty cost provisions for various project types across organization.

The change types can be broadly categorized as:

A. **Engineering Change**

1. New product developments
2. Technological developments
3. Cost outs

B. **Manufacturing Change**

4. Manufacturing Improvements
5. Cost outs
6. Enhanced capacity within same factory
7. Adding new geographical footprint
8. New manufacturing equipment's

C. **Supply Chain**

9. New materials and suppliers
10. New transport solutions etc.

Proactive risk assessments are hence extremely important to access the financial impact brought by the change and provide awareness to the management to decide on whether to accept the risk, reject the risk or mitigate the risk based on financial impact of the change. The idea is to use Shift Left model and quantify the financial risk without waiting for reactive field data or late detailed test information. Models are built on available design, test and operations data and are briefed in next section.

Figure 1: Change Types

Methods

Principles of reliability engineering and testing, supplemented with data analytics offers proven methods to analyze the change impact and convert the expected failures into financial risk looking into the future sales and other financial information.

The content will focus on different methods used to assess the risk depending on problem statement or the change type in consideration.

- ➢ Weibull Analysis (Based on success / failure data)
- ➢ Reliability prediction (Reliability Block Diagram, Strength Stress Interference Model etc.)
- ➢ Predictive Analytics (Multi Linear Regression, Generalized Linear Regression etc.)
- ➢ General/ Advanced Statistical Techniques (Binomial, Poisson, etc.)

Based on the change type and data availability, any of the above listed method can provide a good insight on probability of success or failure the change is expected to bring in thus enabling a fair estimation of financial risk with certain confidence.

The methods are explained in brief as below:

1. Weibull Analysis: To understand the trend of failure rates of products and making life/failure predictions by fitting a statistical distribution to life data from a representative sample of units.

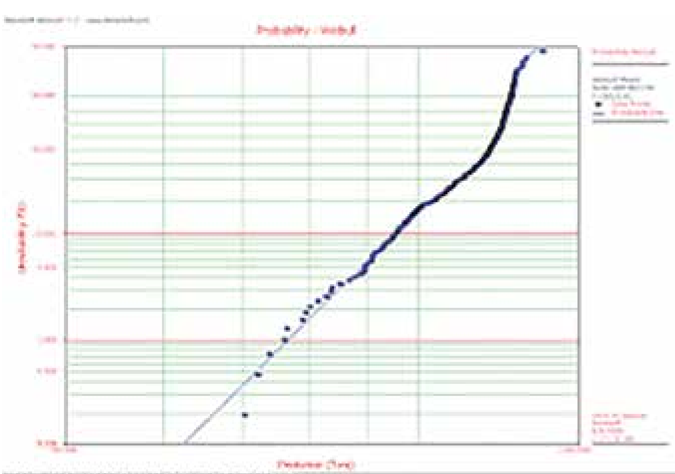


Fig 2: Weibull Analysis (test/field data)

2. Reliability Prediction:

   a. Reliability Block Diagram: Breaks down the whole product into a connected system of various components helping understand the dependencies of each other in the whole functionality and determine Reliability using laws of probability

   b. Strength Stress Interference Model: Uses physics of failure methodology (with physical properties of product/application) to arrive at the product's reliability with the help of interference between the strength of the product and the stress acting on it.

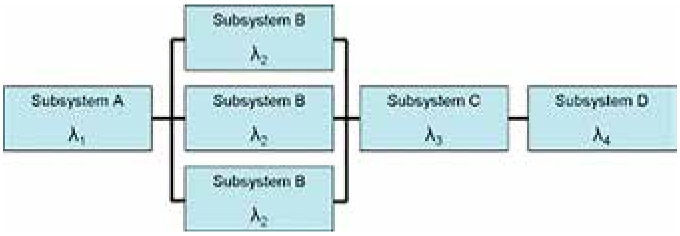


Figure 3: Reliability Block Diagram

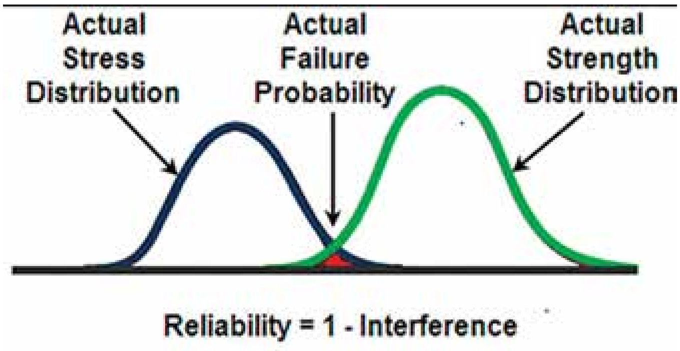


Figure 4: SSI Model

3. Predictive Analytics: Using principles of data mining that deals with extracting information from data and using it to predict trends and behavior patterns. The core of the method lies in capturing relationships between influencing and predicted variables

$$R(t, \mathbf{x}) = e^{-\int_0^t \lambda(u, \mathbf{x}) du} = e^{-t^{\beta} \cdot e^{\sum_{j=0}^{m} c_j x_j}}$$

   Where 'x' are the input predictor variables & 'R' is the reliability at time 't'.

4. General/ Advanced Statistical Techniques: Uses principles of basic statistical methods/distributions to calculate probability of failure.

Any change type listed above goes through required iterations during change development phase. The risks at each of these phases are hence evaluated through use of applicable methods to keep a track on financial risk as the development is in progress. Addition to this such assessments also include the confidence on the numbers by assessing the estimate on a 5 point scale enabling the team to know what they should encourage to make sure that the estimation is right inclined on the indicator. The proactive risk assessments thus inform the direction and magnitude of change, make sure that the risk is effectively communicated & managed/ mitigated and the residual risk acceptable providing the organization an assurance that the suggested change is not imposing severe financial implication on the business or the residual risk is acceptable based on risk benefit analysis

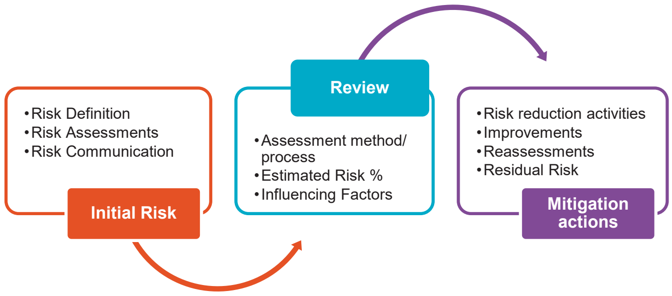


Fig 5: Risk Review & Mitigation

Results – Proactive information

At LM, this structured process of proactive risk assessment has found acceptance not only in reporting the risk but also aims at identification of variables or parameters governing the risk allowing the project owners to drive them down to acceptable level during the developmental phase. The results of the various methods were good enough to cover the suggested change types and provided a good overview to risk review committee at regular intervals. Based on the method used and data (engineering design, operations or test data, inclined by the change type to be assessed) the risk have been identified varying from lower levels to higher levels. Depending on the quantum of risk, improvement is further driven in the organization so that the warranty cost reserves are contained to agreed level.

The manufacturing change refers to operations data, new development change refers to engineering and test data also connects a beautiful relationship of failure as an dependent variables with number of single order or second order independent variables coming from manufacturing or design as the case may be. This then further drives as target to be given considering the cost of reliability enhancement.

The risks uncovered due to different changes also goes through the risk interactions beyond first and second order ensuring such combination of risks is also analyzed and understood for potential mitigation and or avoidance.

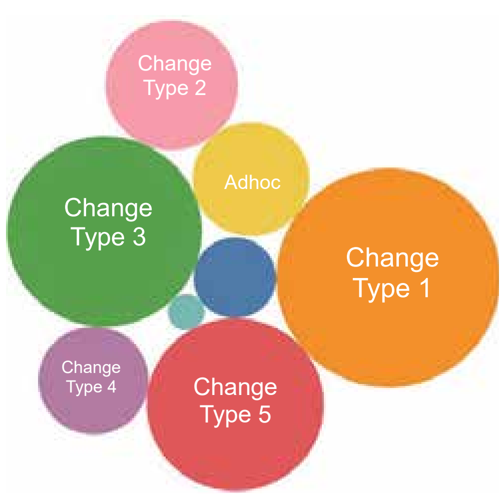


Figure 6: Change Impact Visualization

Conclusion:

With industry moving towards demand of lower cost of energy, there exists a tremendous need to reduce capital cost resulting in driving multiple changes but not limiting to design, manufacturing and supply chain but beyond as well. On other hand the blades are becoming longer and innovations are becoming part of blade solutions. This dynamics certainly appreciates the structured proactive risk assessments followed at LM making sure that each risk is understood, mitigated up to acceptable residual risk thus protecting the capital equipment in times of change. This is possible with the kind of data available from manufacturing and service, test and engineering, inspections and controls.

Proactive risk assessment process also ascertains that feedback to engineering and operations are available in time to drive down potential failures. It has been evident with the amount and variety of risk assessment carried out that this is a good practice which keeps an eye on various change type to protect the financial interest of the organization especially in times when industry shouts for lower levelized cost of energy and cannot afford to wait till the field data speaks about the success or failure of engineering and operational changes.

The future work in this regard can be to have more change type included in the purview of proactive risk assessments, improve the methods of risk assessments to arrive at more precise predictions and continue focus on actionable outcomes from such assessments to mitigate the visible risks earlier in development process. At the same time strengthen the risk interactions at multiple orders and bringing in nets of risk assessments additional change types, external environments to make this a more robust assessment methodology.

Certainly, proactive risk assessments have wide acceptance in terms of providing influential actionable information on imposed technical and financial risk and ways to mitigate it as change becomes the new constant in an attempt towards reducing LCOE. This thus becomes an integral step towards vital objective of protecting the capital intensive equipment the rotor blades and wind turbine for a life of 20-25 years while ensuring realization of inherent safety and reliability.

Snippets on Wind Power

GE to Develop 12 MW World's Largest Wind Turbine in France

General Electric plans to invest more than $400 million over the next three to five years to develop the world's biggest offshore wind turbine, which will have a capacity of 12 megawatts and stand 260 meters (853 feet) tall. With 107-metre blades, longer than a soccer field, the Haliade-X turbine will produce enough power for up to 16,000 households. The new turbine will have a direct-drive power generator rather than a gearbox.

NIWE Issues Expression of Interest for 1000 MW Offshore Wind Farm in Gujarat

National Institute of Wind Energy (NIWE) has invited EOI from suitable and experienced bidders for Development of first 1000 MW commercial Offshore Wind Farm in India, off the cost of Gujarat due at 1700 hrs on 25/05/2018.

CERC - Draft Order on "Calculation of APPC at National Level"

CERC has come out with draft order on Calculation of Average Power Purchase Cost (APPC) at national level and comments were asked by 2/5/2018. The APPC at the National Level has been worked out as ₹ 3.53/ kWh.

TNERC - Final Tariff Order 2018

TNERC has come up with the Final tariff order on 13/4/2018. Wind power tariff is computed with reference to various determinants listed. The tariff works out to ₹ 2.86 per unit without Accelerated Depreciation and ₹ 2.80 per unit with Accelerated Depreciation (AD). This order shall take effect on and from the 1st of April, 2018.

Global Wind Turbine Supplier Ranking in 2017

FTI Intelligence's preliminary rankings for the world's top five wind turbine OEMs released on Feb. 26, 2018 are as follows.

2017 Ranking	Turbine OEM	Change	Commentary
1	Vestas	-	Remains in lead for second year running
2	Siemens Gamesa	+2	Gamesa and Siemens were placed 4th and 6th position separately in 2016
3	Goldwind	-	Remains in 3rd position for second year running
4	GE	-2	Down from 2nd position in 2016
5	Enercon	-	Remains in 5th position for second year running

Amendments in E-way Bill by CBEC for Over Dimensional Cargo

Central Board of Excise and Customs (CBEC), New Delhi has, issued Notification No. 12/2018- on 7th March, 2018 on Amendments made in E-way Bill provisions. The highlights concerning wind industry are:

- Concept of "Over dimensional cargo" has been introduced in respect of determination of the validity period of the e-way bill.
- The validity period for 'Over dimensional cargo' for a distance up to 20 Km would be 'One day'. For others, validity period will be same as earlier i.e. 'One day' for distance up to 100 km.
- "Over dimensional cargo" has been defined in Explanation 2 to Rule 138(10) to mean a cargo carried as a single indivisible unit and which exceeds the dimension limits prescribed in Rule 93 of the Central Motor Vehicles Act, 1988.
- The distance of less than 10 Kms, envisaged under third proviso to Rule 138(3) and proviso to Rule 138(5) has been amended to up to 50 Km.

Compiled By: **Mr. Abhijit Kulkarni**
Business Unit Head - Energy Segment
SKF India Ltd, Pune and
IWTMA Team

New Address of IWTMA - NEW DELHI

IWTMA
INDIAN WIND TURBINE MANUFACTURERS ASSOCIATION

The Corporate Office of IWTMA at New Delhi has shifted at the following address. All the mail should be sent to this address only. All the email addresses will remain the same. Please note the new address for future correspondence.

Indian Wind Turbine Manufacturers Association
Transit House, C-1, Second Floor, Soami Nagar, New Delhi 110017
Phone: 011-41814744, 011-41814755

Wind and Solar Power Generation & Forecasting Regulations & the Way Ahead

Siddhartha Priyadarshi
Vice President & Head
(RE Forecasting)

Vishal Pandya
Co-founder & Director

REConnect Energy

Background

Renewable energy (especially Solar and Wind) industry one of the fastest growing industries in India. The country's solar generation has reached a cumulative capacity of 17.38 GW, while it is 34.04 GW for wind, as of 31st March 2018. In January 2015, the Indian government expanded its solar plans, targeting 100 Billion Dollars of investment and 100 GW of solar capacity, including 40 GW's directly from rooftop solar, by 2022. The recent large scale wind and solar project reverse bidding tenders have brought down their tariffs significantly, while promising to add huge capacity to the grid in the near future.

Last two quarters of 2017 has seen massive additions of renewable power projects to the grid, which accounted for 92% and 93% of the total capacity additions, respectively. Of the 2,887 megawatts of new capacity added in Q4 2017, 2,689 megawatts was based on renewable energy technologies. None of the capacity added during the quarter was based onany fossil fuel technologies. Solar had a massive share of 79% in the total new capacity added in the last quarter.

The Indian grid has recently pipped Japan and Russia to become the 3rd largest in the world. Maintaining grid stability and power quality is a tedious task with its own legacy of issues. Variable generations from renewable energy such as wind and solar plants together are posing significant technical difficulties of grid management. Guarding the future projections of higher share of renewables, it is required to have a good forecast and appropriate balancing action.

Though, both wind and solar forecasts utilize Numerical Weather Prediction (NWP) models to predict variables such as temperature, humidity, precipitation and wind forecasts for wind and solar Photovoltaic (PV) generation are difficult to produce and are most accurate when near real-time meter/SCADA data and detailed static data (e.g., location, terrain, hardware, information etc.).

Regulatory Provisions and Role of Wind/Solar Generators

Keeping the larger renewable capacity addition plans into the consideration, it has been envisaged that more or less every wind and solar generator in the country shall eventually start providing forecast and schedule the energy with the corresponding Grid Operator. In case there are deviations beyond permissible limits, an appropriate deviation settlement charges as applicable through appropriate Deviation Settlement Mechanism (DSM) shall be levied based on the rules set under the applicable DSM regime. Since the Indian Grid is functioning under both the Central and State rules/regulations, based on the applicable jurisdiction, the respective regulators have started defining laws on wind and solar forecasting and scheduling.

The CERC Regulation

The Central Electricity Regulatory Commission published the Framework on Forecasting, Scheduling and Imbalance Handling for Variable Renewable Energy Sources (Wind and Solar) on 7th August, 2015. This Framework is applicable for solar and wind generators that are regional entities, that is, their scheduling and settlement is handled by the respective Regional Load Dispatch Centre (RLDC).

This framework envisages that bulk of wind and solar capacity expected to come online over the next 7 years, in alignment with Government's target of 100 GW solar and 60 GW wind by 2022, shall be inter-state in nature. That is, these generating stations shall sell power within as well as outside the host state, and connect directly to the CTU grid. This will become essential as a few states are rich in solar and wind resources, whereas the Renewable Purchase Obligations (RPOs) shall ensure that the whole country takes advantage of renewable power, while marching towards the national goal of universal electrification. The proposed regulations seek to address the grid integration aspects related to such wind and solar generators directly connected to the State grid.

Given below is the tabular presentation of forecasting regulations issued by various State Electricity Regulatory Commissions (SERCs). It may be noted that most of the regulations issued (draft or final) are more or less in-line with the model regulation on forecasting and scheduling as provided by the Forum of Regulators (FoR).

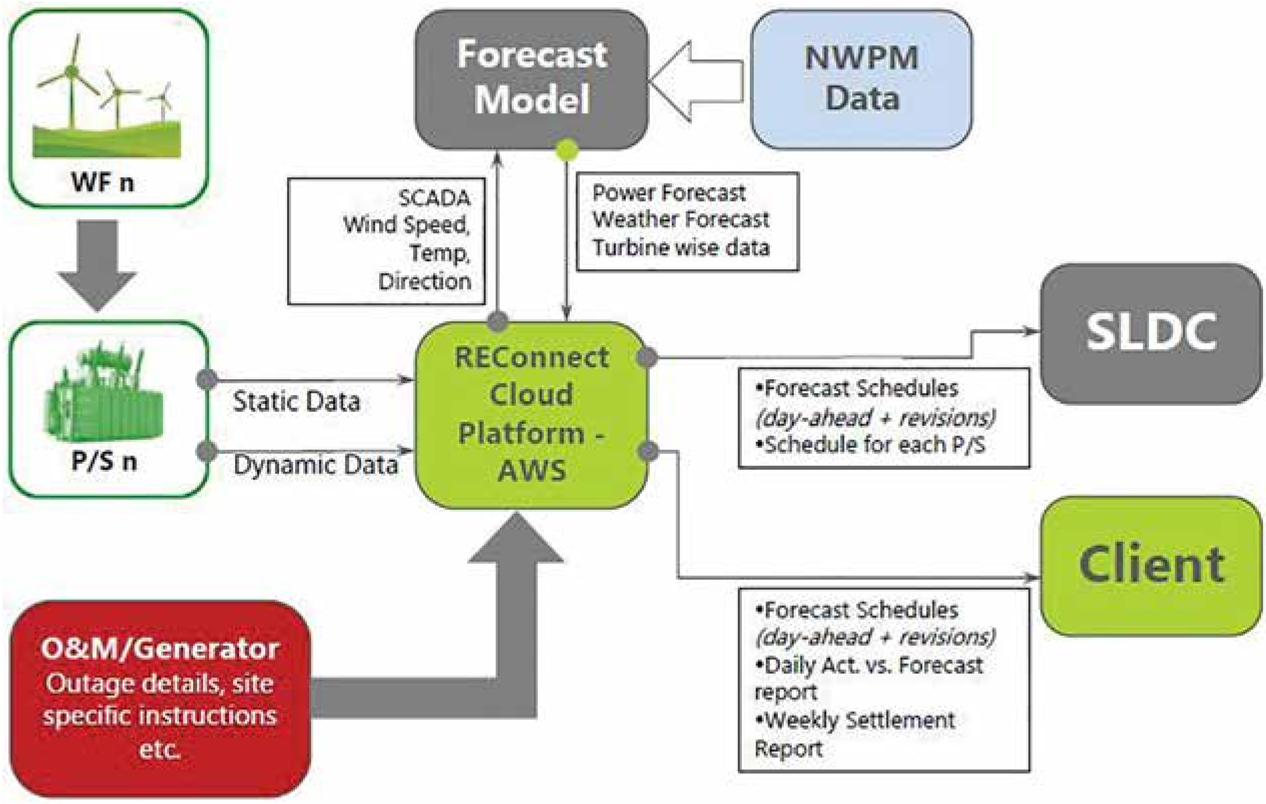
Regulations	Applicable to**	Aggregation	Error Based on	Permissible Deviation	Penalty on Deviation	Status
FoR - Model Regulation	All	Yes	Available Capacity	+/- 15% Old +/- 10% New	Fixed rate of ₹/Unit	-
Odisha (Draft)	>=5MWCGC & OA No min. cap. for others.	No	Available Capacity	+/- 15% for all	Fixed rate as % of PPA	Hearing date TBA
MP (Draft)	All	No	Available Capacity	+/- 15% for all	Fixed rate of ₹/Unit	Final Regulation awaited
Karnataka (Final)	>=10MWWind >=5MWSolar	Yes	Available Capacity	+/- 15% for all	Fixed rate of ₹/Unit	Applicable from 1st June-17
TN (Draft)	All	No	Available Capacity	+/- 5% - Solar +/-10% - Wind	Fixed rate of ₹/Unit	Hearing date TBA
Rajasthan (Final)	>=5MW for both Wind & Solar	No	Available Capacity	+/- 15% for all	Fixed rate of ₹/Unit	Applicable from 1st Feb-18
Jharkhand (Draft)	All	No	Available Capacity	+/- 15% Old +/- 10% New	Fixed rate of ₹/Unit	Hearing date TBA
Chattisgarh (Draft)	>= 5 MW for both Wind & Solar	No	Available Capacity	+/- 10% for all	Fixed rate of ₹/Unit	Hearing date TBA
Andhra Pradesh (Final)	All	No	Available Capacity	+/- 15% Old +/- 10% New	Fixed rate of ₹/Unit	Applicable from 1st Jan-18
Gujarat (Draft)	All	Yes	Available Capacity	Wind: +/- 12% Old +/- 8% New Solar: +/- 7%	Fixed rate of ₹/Unit	Final Regulation awaited
Maharashtra (Draft)	>5 MW	No	Available Capacity OR Scheduled Generation	10% based on Available Cap. OR 30% based on Sch. Gen.	Fixed rate of ₹/Unit	Comments before 30th March-18
Telangana (Draft)	All	No	Available Capacity	+/- 15% for all	Fixed rate of ₹/Unit	Hearing date TBA
Punjab (Draft)	>5 MW	No	Available Capacity	+/- 10% for Intra state +/- 15% for Inter state	Fixed rate of ₹/Unit	Comments by 6th April-18
UP (Draft)	>5 MW	No	Available Capacity	+/- 15% for all	Fixed rate of ₹/Unit	Comments by 6th April-18

TBA - To be announced, Old - Projects commissioned before the regulation, New - Projects Commissioned after the regulation.

The Impact of Aggregation in Scheduling

The Law of Large Numbers: The renewable energy actually becomes more predictable as the number of renewable generators connected to the grid increases thanks to the effect of geographic diversity and the Law of Large Numbers. It is a probability theorem, which states that the aggregate result of a large number of uncertain processes becomes more predictable as the total number of processes increases. Applied to renewable energy, the Law of Large Numbers dictates that the combined output of every wind turbine and solar panel connected to the grid is far less volatile than the output of an individual generator.

Due to the aggregation effect, forecasts for geographically diverse aggregates of solar generation facilities have smaller errors than the forecasts for individual facilities in the aggregate. Local effects, which are more random and more difficult to forecast, tend to average away when the aggregated forecast is looked upon. With aggregation, the impact of forecast errors on individual plants is not as severe because the aggregate forecast of all plants drives the generation scheduling. The image below depicts the data flow diagram for solar/wind forecasting.



The Role of Grid Operators and Govt. of India

While, the renewable energy (wind and solar) producers expected to provide forecast, schedule the energy with the Grid Operators and also undertake payment of DSM Charges, there have also been immense efforts undertaken by the Govt. of India under its very novel project - Renewable Energy Management Centers (REMCs) where multiple forecasting agencies will be appointed in each RE rich states to provide forecast (for each pooling station as well as the entire state or a region as the case may be. Further, the optimised forecast (based on multiple forecaster's outputs) would be generated for each pooling station as well as for the entire state or region as the case may be which may be further utilised by the wind/solar generator to schedule its energy with the Grid Operator which would finally determine the DSM charges payable by the wind/solar generator. The REMCs will further enable all the load dispatch centers (XLDCs) to better manage the grid operations using the state-of-the-art predictive analytics capabilities created under REMCs, even when the overall generation from variable energy sources like wind and solar increases significantly in future.

Conclusion

Looking at the current and expected growth profile of solar and wind sector in the country, and the significant number of states announcing forecasting & scheduling regulations (with many in draft regulation stage), it is evident that wind and solar forecasting and scheduling is finding serious interest and ground among grid operators to resolve wind and solar power integration issues. With the REMCs and its implementation at the horizon, forecasting and scheduling of wind and solar power will diversify at various levels, right from pooling substation to regional level with the collective efforts of wind/solar generators, the grid operators, the regulators, and the above all, the Govt. of India.

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Wind Power Bidding Summary

Details of Bidding (Completed and Planned)				Bid Details			
S.No	Bidding By	Capacity (MW)	Type	Bidders	Bid Capacity (MW)	Rate	State
1	SECI - I (24th February 2017)	1000	Central	Mytrah	250	3.46	Tamil Nadu
				Inox	250	3.46	Gujarat
				Ostro	250	3.46	Gujarat
				Green Infra	250	3.46	Tamil Nadu
				Adani	50	3.46	Gujarat
2	TAMIL NADU (28th August 2017)	500	State	Regen Powertech	200	3.42	Tamil Nadu
				Leap Energgy	200	3.43	
				Nlc	100	3.45	
3	SECI-II (4th October 2017)	1000	Central	Renew	250	2.64	Gujarat
				Orange	200	2.64	Tamil Nadu
				Inox	250	2.65	Gujarat
				Green Infra	250	2.65	Tamil Nadu
				Adani	50	2.65	Gujarat
4	GUJARAT (GUVNL) (21st December 2017)	500	State	Sprng Energy	197.5	2.43	Gujarat
				K.p. Energy	30	2.43	
				Verdant/Sitac	100	2.44	
				Betam Wind/Engie	29.9	2.44	
				Powerica	50	2.44	
				Renew	92.6	2.45	
5	SECI - III (13th February 2018)	2000 MW	Central	Renew	400	2.44	Gujarat
				Green Infra	300	2.44	Gujarat
				Inox	200	2.44	Gujarat
				Torrent	499.8	2.44	Gujarat
				Adani	250	2.45	Gujarat
				Alfanar	300	2.45	Gujarat
				Betam/Engie	50.2	2.45	Gujarat
6	MSEDCL (6th March 2018)	500 MW	State	Adani	75	2.85	Gujarat
				Ktc	75	2.85	Maharashtra
				Inox	50	2.86	Gujarat
				Mytrah	100	2.86	Maharashtra
				Hero	75.6	2.86	Maharashtra
				Torrent	124.4	2.87	Maharashtra
7	SECI - IV (5th April 2018)	2000 MW	Central	Srijan Energy/ Continnum	250	2.51	Gujarat
				Sprng Energy/Actis	300	2.51	Gujarat
				Blp	285	2.51	Gujarat
				Betam/Engie	200	2.51	Tamil Nadu
				Inox	100	2.51	Gujarat
				Adani	300	2.51	Gujarat
				Mytrah	300	2.52	Tamil Nadu
				Renew	265	2.52	
Total Bid Completed		7500					
8	Gujarat (GUVNL) - (Phase - II) With Greenshoe Option	1000 MW	State	RFS was updated on 23rd February 2018			
9	NTPC	2000 MW	Central	RFS was uploaded on 15th March 2018			
10	SECI - V	2000 MW	Central	Bid is announced			
11	MSEDCL	250 MW	State	RFS was uploaded on 13th April 2018			
Total Bidding (Planned)		5250					
Grand Total		12750 MW					

Compiled by: **Rishabh Dhyani**
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