Indian Wind Power

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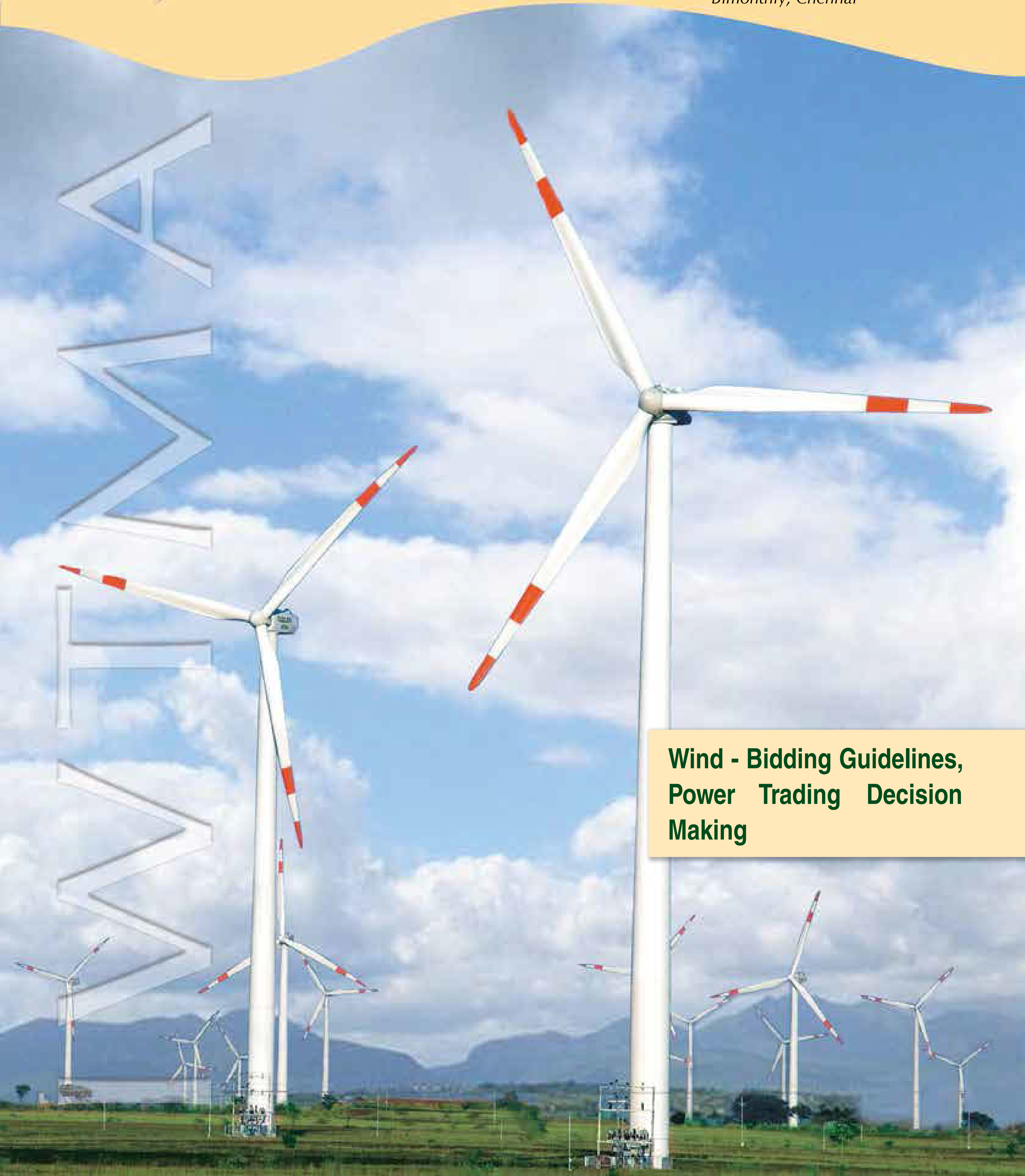


Wind - Bidding Guidelines, Power Trading Decision Making

Expertise offered to Wind & Solar Energy Stakeholders

Research & Development

- Supports multi institutional research on wind energy
- Performance testing of Small Wind Turbines / Aerogenerators
- Empanelment of Small Wind Turbine manufacturers
- Acoustic Noise measurement
- Study of wind-solar-diesel hybrid system

Wind Resource Assessment

- Site condition assessments for wind monitoring & wind farm development and field visits
- Procurement, installation and commissioning of met mast of 50m to 120 m height
- Providing measurement campaign management, assisting clients in the Installation and monitoring of meteorological masts, LIDAR and SODAR stations
- Data collection, management, quality control and wind energy resource reporting
- Analysis of Data with sophisticated software tools and techniques
- Long-Term Trend Data Analysis (NCEP/NCAR/MERRA)
- Turbine array layout design, optimization, field Micro siting and Produce bankable P50 P75, and P90 yield predictions.
- Investment Grade wind energy resource assessment reports (gross/net Predictions, uncertainty analyses, etc.)
- Analysis of existing wind farm operations
- Technical due diligence in complying with international standards.
- Power curve demonstration guarantee test
- Preparation of Tender document for development of wind farm
- Helping the evaluation of tender as one of the tender evaluation committee members.
- DPRs (Detailed Project Reports) preparation through State of art software tool for wind farm developers

Testing Services

- 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

Certification Services

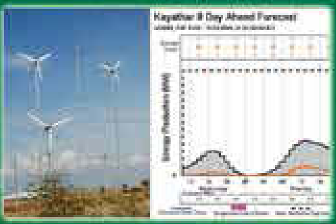
- Accord type approval / type certification to wind turbines in accordance with Indian Type Certification Scheme [TAPS - 2000 (amended)]. Type Certification Services are certified as per ISO 9001 : 2008
- Preparation of Indian standards on wind turbines
- Issue the Revised List of Models and Manufacturers (RLMM) of wind turbines periodically
- Issue the recommendation for grid synchronization to facilitate installation of prototype wind turbines

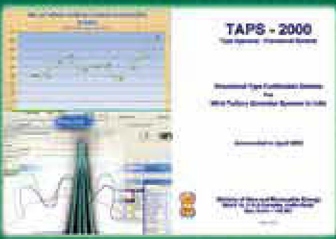
Training

- Capable of providing
- Wind / Solar Resource Measurement & Analysis
- Wind Resource Modelling Techniques
- Wind Speed Statistics / Solar irradiation and Energy Calculations
- Micro-siting and Layout of wind / solar farms
- Wind Turbine / Solar Technology
- Design and Safety requirements as per standards
- O & M practices

Solar Radiation Resource Assessment

- Direct Normal (DNI), Diffused Horizontal (DHI) & Global Horizontal (GHI) irradiation measurements
- Data quality checking
- Solar resource data delivery
- Calibration Laboratory for solar
- Solar Map preparation
- Preparation and vetting of feasibility, DPR of Solar projects





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IWTMA
INDIAN WIND TURBINE MANUFACTURERS ASSOCIATION

Indian Wind Power

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Volume: 3 Issue: 6 February - March 2018

Contents

Indian Wind Turbine Manufacturers Association

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From the Desk of the Chairman - IWTMA

Dear Readers,

Greetings from IWTMA!

I am honoured to be selected as the as the Chairman of IWTMA for the next two years and look forward to further collaborate with the industry to drive the next phase of wind energy revolution in India.

The wind industry is determined and focused on enabling India's energy security, affordable energy for all and transition to a low-carbon economy. With cumulative wind installations of over 32 GW, the industry is ahead of the 30 GW target set by government until FY 2017. I am confident we will surpass the government target of 60 GW much before 2022. The wind industry's commitment towards the Make in India and job creation is unwavering with over 10,000 MW wind turbine manufacturing capacity and a strong supply chain hub truly contributes to the "Make in India" vision.

The industry went through a tough phase and it is the time we convert the challenges into opportunities. Due to the paradigm shift to the competitive bidding and window of 18 months for execution, may restrict the installation in FY 2017-18 to around 1,500 MW. We are thankful to the Ministry of New and Renewable Energy (MNRE) for announcing SECI bids of 6,000 MW and have plans to further announce 10 GW each in FY 2018-19 and FY 2019-20. ISTS waiver is now extended up to 2022. The industry is confident that we will come back stronger.

We appreciate MNRE for accepting our recommendation of continuing with Feed-in-Tariff (FiT) for wind projects below 25 MW to help the MSME sector. It is a very good move and will bring a level playing field for all sections of investors.

The industry is hopeful that the implementation of the recently introduced e-Way Bill system will facilitate faster transportation of wind turbines and components.

The current issue covers articles on Wind Bidding Guidelines and presentations from Windergy India 2017.

I take this opportunity to wish our readers a Happy Holi and a great year ahead.

With Best Wishes

Tulsi Tanti
Chairman

Photo Feature

Indian Wind Turbine Manufacturers Association conducted an Extraordinary General Meeting on Wednesday, 10th January 2018 at Chennai to elect New Executive Committee. The following members were nominated as Executive Committee Members for 2 years term (2018-19):

Chairman: Mr. Tulsi Tanti

Executive Committee Members: Mr. Ramesh Kymal, Mr. Madhusudan Khemka; Mr. Sarvesh Kumar, and Mr. Hemkant Limaye.

Extraordinary General Meeting being conducted on 10th January 2018 at Chennai

From Left to Right: Dr. Sanjiv Kawishwar, Mr. V.K. Krishnan, Mr. Pradeep Shankar, Mr. Vivek Raut, Mr. A. Gurunathan, Mr. Ajay Mehra, Mr. Madhusudan Khemka and Mr. S. Ravichandran

From Left to Right: Mr. D.V. Giri, Mr. Sarvesh Kumar, Mr. Chintan Shah and Mr. Tulsi Tanti

From Left to Right: Mr. Ramesh Kymal, Mr. Hemkant Limaye, Mr. Amit Kansal, Mr. Murali Rajaram, Mr. K. Bharathy, Mr. Abhijit Kulkarni, Mr. Amar Variawa, Mr. Sivakumar, Mr. Harikrishan Palani and Mr. Satish Goyal

New Executive Committee of IWTMA

From Left to Right: Mr. Madhusudan Khemka, Mr. Tulsi Tanti (Chairman), Mr. Sarvesh Kumar, Mr. Ramesh Kymal and Mr. Hemkant Limaye

Mr. O.P. Taneja, Associate Director, IWTMA, New Delhi spoke on Scheduling and Forecasting in Rajasthan - An IWTMA Initiative at the workshop “Current Practices in Wind and Solar Forecasting" on January 22 2018 at Chennai.

Risk Constrained Short-term Trading Decision Making for Wind Power Producer under Renewable Energy Policies

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World Institute of Sustainable Energy, Pune

Parul Mathuria
Post Doctoral Fellow, Department of Industrial Management Engineering
Indian Institute of Technology, Kanpur, India

Electricity grid, often sought to be as the most critically engineered system, has gone through a series of transition right from its inception. For several decades it was completely owned by a single large entity which exercised its authority in all the aspects of operation concerned with generation, transmission and distribution within its predefined domain. Such utilities were obliged to dispatch services to their customers with the adequacy and least interruption possible. This setup was termed as the vertically integrated utilities in a sense that these were connected vertically with each of them assigned with the predefined set of tasks to be performed with the common objective of providing electricity to the end consumer.

The price of electricity that a generation company receives in a competitive market depends on many factors such as bidding price of all market participants, load demand, unit outages, etc. It is uncertain and highly volatile. Consequently, the generation company always faces the risk of uncertainty in terms of the revenue. Generation company has options to sell in more than one market and therefore it can schedule its energy into more than one market in order to maximize profitability at minimum level of risk. Main factor of risk is the non-storable nature of electricity, which results in high price volatility. Recognizing the risk involved and its management is essential for generation companies in a competitive market.

The intensity of risk is much more severe in case of non-conventional generators such as wind power producers due to its utter dependency on the meteorological conditions hence the forecast errors pertaining to wind availability, market clearing prices play an important role in strengthening or weakening their position in the market. In order to sustain in a deregulated market and make a prominent contribution by reducing the impact of uncertainties such as wind availability, market prices and energy deviation, the wind power producer need to adopt an optimised approach to complement decision making under uncertainties.

Due to forecast errors the chances for deviation in real time is too high for wind power producer and to complement this with the energy storage device and flexible generation plants simply boils down the profit by increasing the additional cost. Hence a pragmatic solution can be attained by designing the trading strategy appropriately by handling the associated uncertainty parameters.

To make risk constrained decision under uncertain market conditions and availability of resource, stochastic optimisation is proposed to quantify the risk and aid the decision making related to trading with an objective to establish trade-off between profit maximisation and risk minimisation for a wind power producer.

Over the years, various reformative measures both in legal as well as technical terms have been proposed and implemented to boost the inculcation and promotion of renewable energy. The support from the policy makers have proved to be a boon to RE Generation companies with the introduction of measures such as RPO (Renewable Purchase Obligation) on the load serving entities to purchase certain percentage of power from renewables. Various financial support schemes to overcome the heavy capital cost of installing the RE were proposed in the last decade such as incentives, subsidies, PTC (Production Tax Credit), FIT (Feed in Tariff) and REC (Renewable Energy Certificate), which have added up the share of renewables in the grid. These policies stimulate the deployment of RE by driving markets, providing certainty in the investment and enhancing decision-making process for an RE generator facing the inherent uncertainties of output as well as the price volatility. Using statistical analysis, policy reforms and best design practices this proposed work analyses the impact of state-level policies on renewable energy deployment in order to understand better the role of policy and inform policy makers on the mechanisms that provide maximum benefit.

Objectives and Scope of the Work

1. To derive the risk constrained trading strategies for a wind power producer in a competitive market.
2. To provide an effective way to limit the risk on profit variability by introducing a decision-making model involving

pool offering, self-scheduling and RE policy financial instruments.

3. Maximize the profit function of a WEG by considering a linear cost modelling mechanism.

4. To envisage the role of various promotional policies like FIT (Feed in Tariff), REC (Renewable Energy Certificate) in promoting RE and aiding the process of decision making under uncertainty.

5. To use a stochastic programming framework to formulate the model stated in objective 2, 3 and 4 and to recast this formulation into an easy-to-solve mixed-integer linear programming problem.

Risk Management

Risk management is the systematic process of attaining the desired trade-off between the risk and profit from a particular trading strategy. In other words, it aims at establishing fine balance between the profit maximisation and risk minimisation.

Figure 1: Risk Management Workflow

Risk management encompasses three basic aspects: risk identification, quantification and control. This thought can be more appropriately put forward by the following pictorial representation wherein each step is assigned with the pre specified task to be performed.

Risk Measurement Techniques Employed:

1. Variance

It measures the risk in the portfolio. Its major drawback is the fact that it equally penalizes return fluctuations above and below its expected value which might generate misleading results in case of asymmetrical distributions which is often the case for the profit function in a power portfolio.

$$Var(\pi) = \sigma^2 = E[(\pi - E(\pi))^2]$$

2. Value at Risk (VaR)

One of the popular techniques of risk measurement is Value at Risk (VaR). VaR is defined as expected loss for an adverse market movement with a specified probability over a particular period of time. VaR is a value which states that the portfolio will lose less than that amount over a specified period of time with a specified probability.

Therefore, one reason for the rapid acceptance of VaR as a risk measurement tool is that it provides a measurement of the maximum deviation in the value of a portfolio for a set time frame to a given certainty considering market conditions.

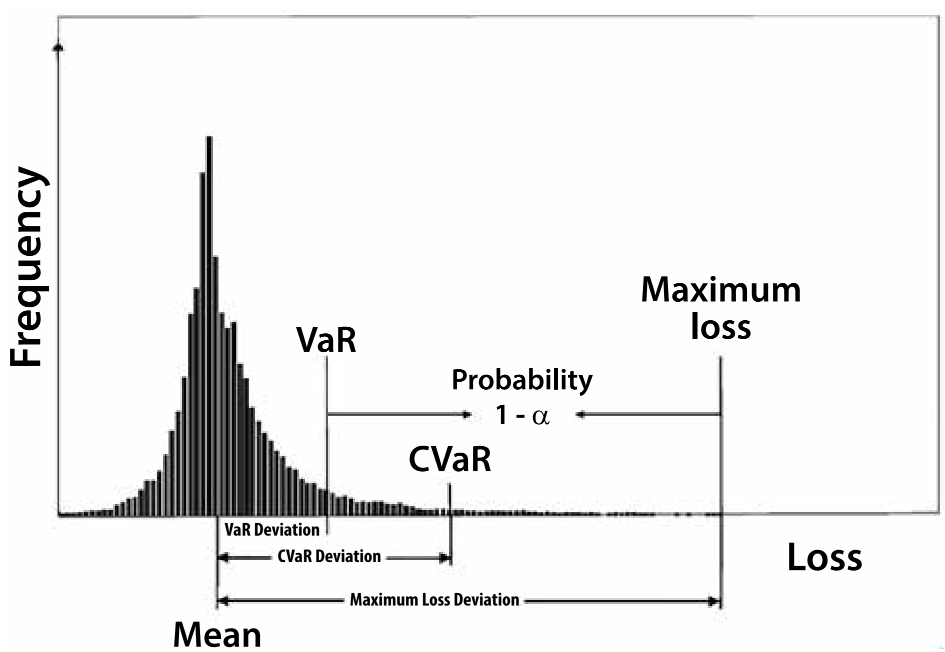


Figure 2: Illustration of VaR and CVaR with a Sample Confidence Interval of 95%

3. CVaR (Conditional Value at Risk)

An important variation of VaR is the Conditional Value at Risk or CVaR. Where VaR establishes the loss at the 95% level, it does not measure the expected loss. CVaR is the integral of the loss distribution and measures the expected amount of loss given that it is greater than the 95% level. Also, because it is an integral it is inherently better behaved mathematically and more tractable for portfolio optimization.

Decision Framework for Wind Power Producer

Decision making for wind power producer is governed by the effective handling of the uncertainty parameters which are mainly the forecast of wind speed and market clearing prices. Two types of modelling approaches are:

1. Deterministic or robust optimization
2. Stochastic optimization

a. Deterministic or Robust Optimization

In this approach the solution behaves well in all the possible realizations and gives equal weightage to all the scenarios.

b. Stochastic Optimization

Stochastic optimization (SO) methods are optimization methods that considers that the data uncertainty is random and can be modelled by the use of probability distribution function and is basically multi stage approach that considers weight of the scenario to generate and reduce scenarios.

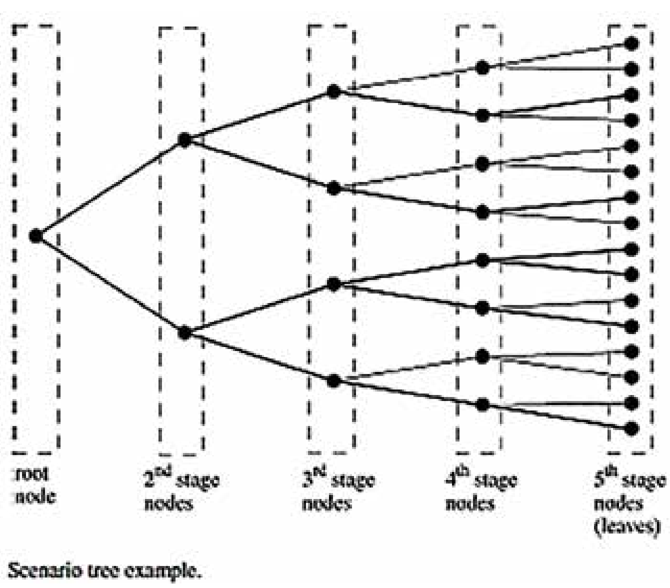


Figure 3: Scenario Generation for Stochastic Optimisation

For stochastic problems, the random variables appear in the formulation of the optimization problem itself, which involve random objective functions or random constraints. Stochastic optimization methods also include methods with random iterates.

Uncertainty Optimization: Uncertainty optimisation can be single period or multi period which generates multiple scenarios, which can be reduced to eliminate scenarios with very low probability and contract the scenarios while maintaining the original distribution.

Considering a wind power producer participating in a pool based electricity market categorized by 3 different trading namely Day Ahead(DA), Adjustment Market(AM) and Balancing Market(BM) and additional facility to avail policy benefits of REC & FIT and not exercising or capable of exercising market power as functioning as a price taker. The objective is to maximise profit from day ahead and adjustment market and reducing imbalance penalties.

Decision framework and the time frame work of a wind power producer can be understood from the diagram given below wherein the day ahead market spanning for 24 hours for day d is closed at the tD hour of the previous day d-1 usually considered 14 hours before.

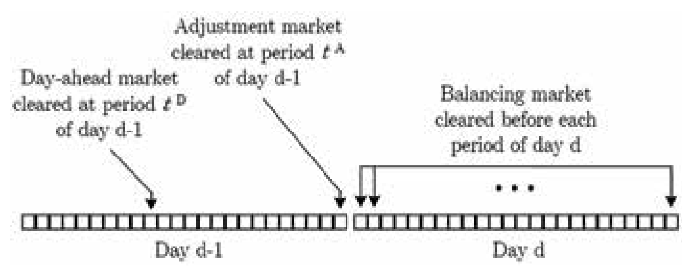


Figure 4: Decision Framework of the Wind Power Producer

Due to the obvious delay between closure of the day ahead market and the real time horizon an adjustment market is introduced to take corrective actions with a greater accuracy and reduce uncertainty.

A wind power producer typically faces following uncertainties in short-term trading:

- Wind speed uncertainty
- Day ahead market prices
- Adjustment market prices
- Imbalance penalties

Hence a multi stage stochastic optimisation can generate the optimal offering bids that can hedge the risk of profit variability. In terms of long-term planning various issues of uncertainty are considered by a wind power producer that includes basically the risk of recovering the huge capital cost simultaneously governed by different factors such as management and operational cost, replacement costs truly accounted by the discount rates involved over the entire life time of the plant. The role of policy instruments such as FIT and REC in profit maximisation has been analysed in aiding informed decision making.

Stochastic Programming Model

Decision-making issues pertaining to uncertain parameters, enforces the decision maker to make optimal decisions throughout the decision horizon with incomplete information. The decision horizon considered is divided across number of stages wherein each stage represents a point in time where decisions are made or where uncertainty vanishes partially or totally. The information available to the decision maker at every point or stage is different. On the basis of the number of stages considered the problem is differentiated as two stage and multistage stochastic programming problems.

This decision-making process is broadly classified into two different types on the basis of time horizon at which the decisions are made:

1. First-stage or here-and-now decision: The decision that are made before the realization of the stochastic processes are known as here-and-how decision wherein the variables representing these decisions do not depend on the realization of the stochastic process.

2. Second-stage or wait-and-see decision: Those decisions that are made after the actual realization of the stochastic process are termed as wait-and-see decisions. Consequently, these decisions depend on the realization of each stochastic process involved. If the stochastic process is represented by the set of scenarios, then the 2nd stage decision variables are defined for every single scenario considered. Lastly, these sets of scenarios specifying the uncertainty associated with wind speed and market clearing price in this particular problem of wind power producer problem can be arranged in a scenario tree in a form depicted in Figure 5.

Basically, the steps involved in building a scenario tree are as follows:

1. First N_D price scenarios are generated for the day-ahead market price realization.
2. Then for each realization of the Day-ahead (DA) market prices, N_Δ scenarios are simulated which model the difference between the Day-ahead (DA) and Adjustment market (AM) prices.
3. Then for each scenario of the AM prices, N_P wind power realizations are generated.
4. Finally, N_I imbalance price ratio scenarios are simulated, for each wind power realization.

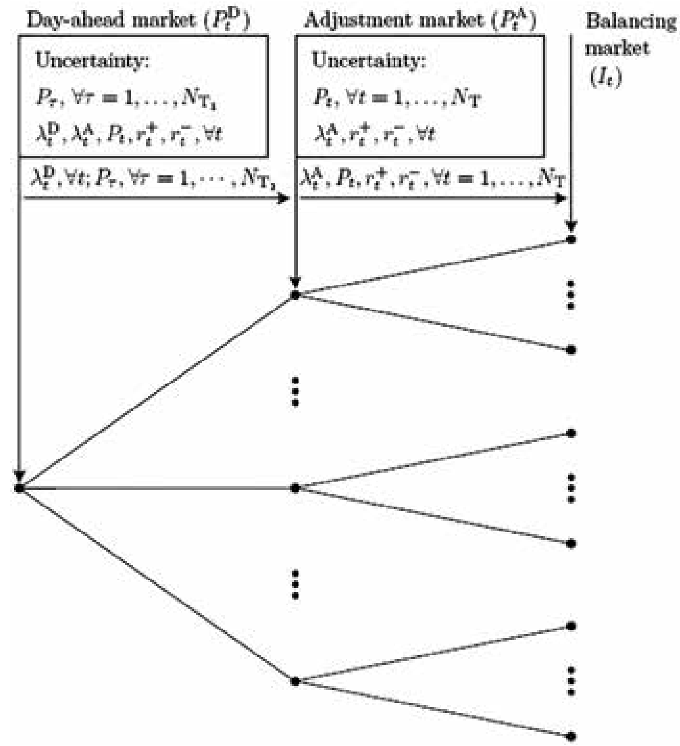


Figure 5: Flow Chart for Decision-making Scenario Tree

Hence, it is concluded that for each scenario ***w*** in the scenario tree so built by above procedure is made up of a set of vectors illustrating the plausible realizations of the stochastic processes involved in the wind power producer problem, namely, market prices and wind generation.

Mathematically, the above theory can be expressed as:

Scenario

$$w = \left[\lambda_{tw}^D, P_{\Upsilon w}, \lambda_{tw}^A, P_{tw}, r_{tw}^+, r_{tw}^+\right], \forall t = 1,2.....,N_T, \forall \Upsilon = 1,2.....,N_{T1}$$

Where $\lambda_{tw}^A = \lambda_{tw}^D + \Delta\lambda_{tw}$

Similarly, each scenario *w* in the scenario tree has a pre-defined probability of occurrence π_w computed as the product of the probabilities associated with vectors λ_{tw}^D , $\Delta\lambda_{tw}$, $P_{\Upsilon w}$, P_{tw} and r_{tw}^+, r_{tw}^+. Needless to mention that the summation of all these probabilities π_w over the whole set of scenarios Ω must be equal to 1, i.e. $\sum_{w=1}^{N_\Omega} \pi_w = 1$.

Therefore, the total number of scenarios composing the tree is

$$N_\Omega = N_D N_\Delta N_P N_I$$

Last, the scenario tree formed above is fed into a 3 stage stochastic programming model wherein each stage represents a market. Following is the sequence of stages and decisions:

1. Offer strategy is chalked out for the day-ahead market and the resulting energy selling offers are submitted to this market for every period of the market horizon. At this stage, decisions made are based on the plausible realizations of the stochastic processes involved i.e. wind power production corresponding to the wind speeds and market prices (DA, AM and BM).

2. Once the DA market prices are known for each time period then the amount of energy to be sold/bought in/from the AM is decided. More precisely the moment at which these decisions are taken, the 24 hourly wind power generated and DA market prices in the time period between the closures of the DA and AM are known. Although, the wind power production and the AM and BM prices for the rest of the market horizon are still uncertain parameters. Therefore in the 2nd stage i.e. for every DA market price realization, decisions are made based on plausible scenarios of wind power production and the AM and balancing market prices. Herein the wind production scenarios, spanning the entire market horizon are available at this stage and are generated knowing the actual wind production in the periods between the closures of the DA and AM.

3. Finally, the last stage of this stochastic programming approach is determined by the realization of the AM prices, the wind power generated in the time periods spanning the whole market horizon and the associated imbalance prices. Hence at this stage the deviations incurred by the wind power producer in each one of these periods is known and the consequent cost for imbalance is computed depending upon the penalty scheme applicable for the upward and the downward regulation.

PROBLEM DESCRIPTION

Overall Objective Function:

Max (P_{FIT} λ_{FIT} + P_{DA} λ_{DA} + P_{AM} λ_{AM} + P_{REC} λ_{REC} ± Imbalance cost – LCOE* P_{TS})

i.e.

Maximize Z =

$$\sum_{w=1}^{N_w} \sum_{t=1}^{N_T} \pi_w (\lambda_{tw}^D P_t^D d_t + \lambda^F P_t^{FIT} d_t + \lambda^R P_{tw}^{REC} d_t + \lambda_{tw}^A P_{tw}^A d_t + \lambda_{tw}^D r_{tw}^+ \Delta_{tw}^+ - \lambda_{tw}^D r_{tw}^- \Delta_{tw}^- - LCOE * P_{tw}^{TOTAL})$$

$$+ \beta(\zeta - \frac{1}{1-\alpha} \sum_{w=1}^{N_w} \pi_w \eta_w)$$

Subjected to decision variables $P_{tw}^D \forall t \forall w; P_{tw}^A \forall t \forall w; P_t^{FIT} \forall t; \Delta_{tw}^+ \forall t \forall w; \Delta_{tw}^- \forall t \forall w; \eta_w \forall w; \zeta$

	Decision variables	Major constraints
1st stage	$\lambda_{tw}^D, \lambda_t^F, P_t^F, P_{tw}^D$	$0 \le P_{tw}^D, P_t^F \le P^{\max} \forall t \forall w;$
2nd stage	$\lambda_{tw}^A, P_{tw}^A, P_{tw}^{REC} P_{tw}, r_{tw}^+, r_{tw}^-$	$0 \le P_{tw}^{TS} \le P^{\max} \forall t \forall w;$
3rd stage	$\Delta_{tw}^+, \Delta_{tw}^-$	$\Delta_{tw} = d_t (P_{tw}^{TS} - P_{tw}^{pool}) \forall t \forall w;$

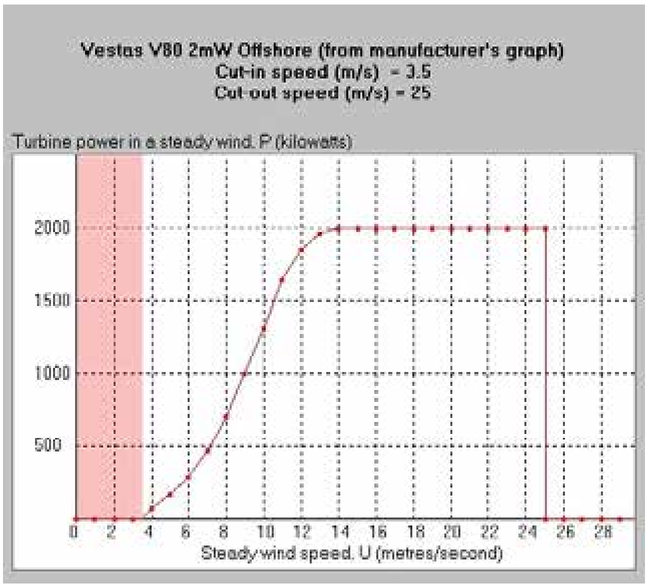
PROBLEM DESCRIPTION

$0 \le P_{tw}^{D} \le P^{\max} \forall t \forall w;$	Limit on power traded in Day-ahead market
$P_{tw}^{pool} = P_{tw}^{D} + P_{tw}^{A} \forall t \forall w;$	Power traded in pool is sum of that traded in DA & AM
$0 \le P_{tw}^{pool} \le P^{\max} \forall t \forall w;$	Limit on total power traded in pool
$\Delta_{tw} = d_t (P_{tw} - P_{tw}^{pool}) \forall t \forall w;$	Total deviation calculated as difference between actual and scheduled
$0 \le \Delta_{tw}^{+} \le P_{tw} d_t \forall t \forall w;$	Limit on positive deviation in pool
$0 \le \Delta_{tw}^{-} \le P^{\max} d_t \forall t \forall w;$	Limit on negative deviation
$P_{tw}^{pool} = P_{tw}^{REC} \forall t \forall w;$	Power traded in pool eligible for REC credit
$P_{tw}^{TOTAL} = P_{tw}^{pool} + P_t^{FIT} \forall t \forall w;$	Total power scheduled is sum of power traded in FIT contract and pool
$P_t^{FIT\_\min} \le P_t^{FIT} \le P_t^{FIT\_\max} d_t \forall t \forall w;$	maximum and minimum cap on power traded in FIT

CASE STUDY & RESULTS

A case study for PJM electricity market is considered. Specifications of the case study are listed below:

- Installed capacity 50 x 2 MW = 100 MW
- Turbine model VESTAS N80/2000
- Hub height 100 m
- Location AECO zone (USA)
- Rotor diameter 80 m
- Cut in speed 3.5 m/s
- Cut out speed 25 m/s
- Hub height 100 m

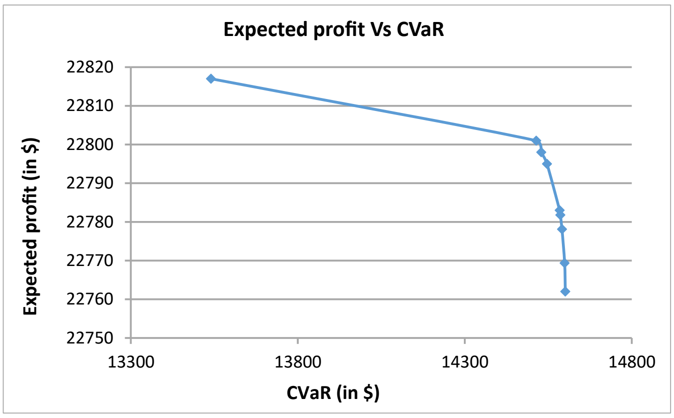


- Total no. of scenarios for DA, AM & BM = 288

Summing up the entire profit function of trading in various mechanisms and various floors against the CVaR, a wind power producer can set the level of his risk aversion ability. The value of overall expected profit against the risk parameter CVaR at various level of risk aversion parameter, beta can be represented in tabular manner as:

β Beta	Z Objective function	CVaR (in $)	T Total profit (in $)	Total Revenue (in$)	Total Cost (in$)	Total Pool Revenue (in $)
0	22774.54	13540	22817	26568	3751	23120
0.085	23981.58	14514	22801	27584	4783	23200
0.2	25636.38	14529	22798	27579	4781	23197
0.311	27235.64	14546	22795	27644	4849	23220
0.39	28374.44	14584	22783	27783	5000	23266
0.8	29960.9	14586	22781.78	27789	5007.22	23267
1	34290.19	14591	22778.12	27809	5030.88	23273
3	37178.44	14599	22769.37	27845	5075.63	23281
10	66061.06	14601	22762	27873	5111	23288

Table 1: Financial Assessment of Various Parameters at Varying Risk Level



The resulting curve is known as efficient frontier which aids the decision making for a wind power producer to decide his ability to take risk. It can be seen that for a small drop in profit a significant increase is marked for the CVaR. Higher is the volatility of the stochastic process involved, the more advantageous is the use of proposed stochastic optimisation model having the cost component as well the policy instruments. It can be observed that there is steep decrease in profit at varying risk levels as against the heavy increase in CVaR. The introduction of policy measure increases the expected profit by appropriately modelling the uncertainties and deciding the allocation among available trading floors.

Conclusion

1. A multi-stage stochastic modelling of the wind producer problem gives a sequential way to consider the uncertainty effect at different stages in long-term as well as short-term decision-making problems.
2. Risk management in the wind power producer problem is attained by the decrease in expected profit by assigning different weightage to risk adversity.
3. Certainty gain effects are crucial in making corrective actions just before the real time so that the profit function can be appropriately modelled.
4. Trading strategy considering RE policies help in informed decision making and to deal with the uncertainty appropriately stabilising the wind power in the market, thereby increasing the profit.

List of Symbols

t	Index of time periods running from 1 to N_T
w	Index of scenarios running from 1 to N_W
P_t^D	Power offered by the WPP in the day-ahead market for time period *t* (in MW)
P_{tw}^A	Power offered by the WPP in the adjustment market for time period *t* and scenario *w*
P_{tw}^S	Power production scheduled by the WPP for pool in time period *t* and scenario *w*
P_{tw}^{TS}	Total power scheduled by the WPP in time period *t* and scenario *w*
P_t^F	Power offered by the WPP in the Feed-in-Tariff contract for time period *t*
P_{tw}^{REC}	Power traded by the WPP in REC mechanism the for time period *t* and scenario *w*
Δ_{tw}	Total energy deviation incurred by the WPP *w.r.t* schedule in time period *t* and scenario *w*
Δ_{tw}^+	Positive deviation incurred by the WPP *w.r.t* the schedule in time period *t* & scenario *w*
Δ_{tw}^-	Negative deviation incurred by the WPP *w.r.t* the schedule in time period *t* & scenario *w*
ζ	Auxiliary variable used to compute the conditional value at risk, CVaR
η_w	Auxiliary variable in scenario *w* used to compute the CVaR
λ_t^A	Adjustment market price in time period *t* per MWh
λ_t^D	Day-ahead market price in time period *t* per MWh
λ_t^{UP}	Price for upward energy resulting from the balancing market in time period *t*
λ_t^{DN}	Price for downward energy resulting from the balancing market in time period *t*
λ_t^+	Price of positive imbalances incurred in time period *t*
λ_t^-	Price of negative imbalances incurred in time period *t*
P_t	Wind power production in time period *t*
r_{tw}^+	Ratio between positive imbalance price and day-ahead market price in time period *t*
r_{tw}^-	Ratio between negative imbalance price and day-ahead market price in time period *t*
λ_t^{REC}	REC market price in time period *t* per MWh
λ_t^{FIT}	FIT market price in time period *t* per MWh

Maintenance and Service Strategies for Aging Wind Farms

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As a wind turbine ages, decision makers are faced with many potential issues that need resolving. Naturally, changes and advancements in technology can mean that particular parts have been discontinued. And even if the components are available, they may no longer be supported by the OEM or be under warranty. Moreover, due to market consolidation, the company that previously supplied the product or service may no longer exist.

With time taking its toll on machinery, reducing both performance and efficiency, it would be easy to assume that older models would be rendered obsolete. Fortunately, this often doesn't have to be the case.

Older wind turbines potentially offer operators many benefits. Firstly, over years of use, they build up a clear and comprehensive understanding of a wind turbine. Whether this be maintenance requirements, machine behaviour, or even simple functionality, operators become familiar with the machine and can confidently deal with, or even avoid, the typical issues.

One particularly useful strategy is the concept of repowering older wind turbines. This is where worn parts of a turbine are replaced with newer, more effective components. Not only does this cost less than purchasing and commissioning a completely new turbine, it is also much quicker and easier to implement for operators. By upgrading turbines and benefitting from reusable parts, electricity can be produced more efficiently and cost-effectively.

However, it is important to have an effective strategy in place. Making use of service providers, such as OEMs or independent companies, is crucial in sourcing the right equipment and components for dated wind turbines. By evaluating and upgrading, operators can use the resources at their disposal to define a clear and economically viable strategy, an example being the aforementioned practice of repowering.

It is not just operators that are becoming aware of the concept of profiting from older turbines. OEMs and spare parts dealers are moving with the times too, supporting operators in breathing new life into old machinery. SKF is involved in this trend too, offering engineering support and supplying bearings – meaning old turbines remain functional for many years to come.

Overall, despite the limitations to maintaining older wind turbines, renovation and reuse actually present operators with a significant range of opportunities. If they take the right approach, operators are able to keep their wind farms running without the need for major overhaul or purchasing completely new machinery. Not only does this save time, it is also cost-effective – benefitting both operators and renewable energy in general.

If a bearing is not damaged beyond repair, or has an estimated 30 percent of its service life remaining, then remanufacturing may be the best option. It can also represent a viable solution when a bearing has exceeded its shelf life or requires an upgrade such as black oxide coating.

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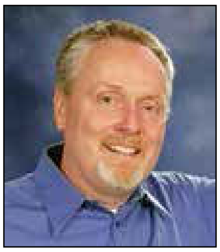
Paving the Way for Remote Sensing Adoption in India



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Introduction

A key question in developing and financing a wind project is how much energy will it produce? This depends on wind – a variable resource that dramatically affects the cash flow of a wind project. Wind resources vary from night to day, from day to day, from month to month, and from year to year. An accurate estimate of both the mean wind speed, and the variations around that mean are crucial to understanding the potential risks and rewards of developing a wind project.

For over 30 years, the primary wind measurement tool has been a meteorological mast (or "met tower") equipped with anemometers, vanes, and data loggers that record wind speed and direction. Every modern wind energy project, in contributing to an industry worth billions of dollars, has been cost-justified based on this technology. Ideally, a met tower would be tall enough to gather measurements throughout the entire height range of the rotor, but this is impractical, especially with the ever-increasing hub heights of modern wind turbines (Figure 1). In practice, due to costs, permitting, and other constraints, most met masts don't reach higher than 80-100 meters. To quantify the winds at higher hub heights and throughout the depth of the rotor plane, wind developers, independent engineers and investors must extrapolate the measured values upward, using wind shear values derived from lower heights. However, this process is prone to error (as much as 10-15%), increasing the uncertainty of the energy estimate. This uncertainty will only worsen as average turbine heights continue to extend beyond 100 meters.

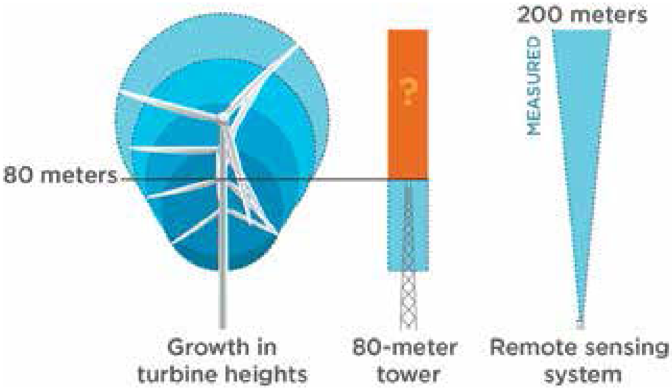

Figure 1: Value of Remote Sensing as Turbine Hub Heights Grow

Today, ground-based remote sensing technology supplements towers, measuring wind speed and direction at much higher heights than met masts (up to 200 m; Figure 1).

One particular remote sensing technology is SoDAR (SOnic Detection And Ranging). As with other remote sensing technologies (LiDAR, radar), SoDAR wind profilers collect measurements of horizontal wind speed and direction at heights up to ~200 m above ground, significantly extending past the height range of met towers. They do this by measuring the Doppler frequency shift of energy pulses that are sent upward, reflect off of turbulent eddies within the air, and return to the device, where the Doppler shifts are recorded and converted to wind vectors. SoDAR uses sound pulses, whereas LiDAR uses infrared light (scattered off of aerosols) and radar uses microwaves (scattered off of turbulence or precipitation). Each of these technologies have their unique advantages and challenges. The characteristics of SoDAR that is attractive for wind resource assessment include: its consistent accuracy without the need for periodic calibration; its portability; its low power requirement; and its rugged ability to withstand long, unattended, self-powered deployments in remote and diverse locations, under harsh weather conditions (Figure 2).

Figure 2: Triton Wind Profiler in Diverse Environments

However, as relative newcomers, remote sensing technologies face a high bar for acceptance by the wind resource measurement community, which has vast experience and a high comfort level with met towers and cup anemometry. To work toward acceptance, remote sensing manufacturers, their customers, and third-party consultants have conducted a number of comparison studies between remote sensing devices and collocated met towers. Vaisala, in partnership with various customers and consultants, has conducted a number of such studies on the Triton Wind Profiler, a SoDAR-based remote sensing device. This article will summarize results from our global Triton validation study [1]. At the time that study was conducted, there were insufficient data sets from collocated Triton and met tower pairs in India, but several are now available, and so we present specific results from two Indian Triton/met tower collocations. Of particular interest to the Indian market is the question of how well the Triton performs in the monsoon season, not just because it is by far the windiest time of year, but also because SoDAR measurements are complicated by heavy rainfall, so there is a concern that data recovery in the monsoon season using SoDAR might be challenging.

The Global Triton Validation Study

In 2015, we conducted a global validation study in which it compared 30 Triton/met tower pairs across the globe. The purpose of this study was to quantify customer-experienced accuracy of commercially deployed Tritons in a variety of geographic and meteorological conditions, with a sample size that was large enough to generate meaningful statistical results. Characteristics of the study are summarized in Table 1, and the approximate geographic distribution of the pairs is shown in Figure 3. The study attempted to address two key questions that a potential remote sensing user would likely ask:

1. Will the device recover a sufficient amount of data to give confidence that it is capturing the actual wind distribution at the site?
2. What is the accuracy of the device compared to a met tower, primarily in terms of measuring the mean wind speed over an extended period of time?

Table 1: Details of Global Triton Validation Study	
Number of Triton/met tower pairs	30
Number of tower sensor heights compared	100
Range of tower heights	34 – 120m
Range of distances from met tower to Triton	70 – 220m (average: 134m)
Elevation differences between met and Triton	< 6m (mostly < 2m)
Number of Tritons with original/upgraded speaker array	18 / 12
Periods of measurement	4 – 25 weeks
Customers / Users providing data	11
Terrain	Mostly flat
Frequency of rain occurrence	Low to moderate

To address the first question, we examined the data recovery rate averaged across the 12 Triton units used in the study that employed the latest version of the Triton speaker array (known as the "Triton Performance Upgrade", or TPU). The recovery rate is defined as the percentage of time that the device yields a valid measurement at a particular height, where "valid" means that the measurement has passed some standard quality control (QC) procedure. Those results are shown in the upper panel of Figure 4. Even at heights up to 100 m, the recovery rate remains above 95%, only slightly lower than typical data recovery rates for met towers.

Figure 3: Sites included in Global Validation Study

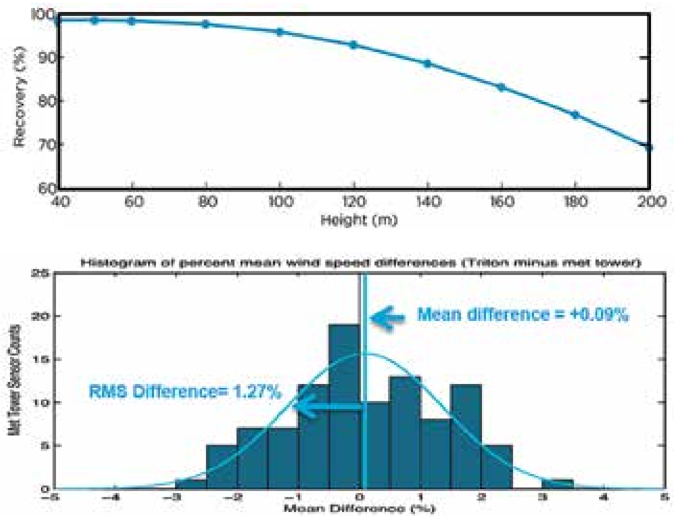

Figure 4: Validation Study Results - Top: Data Recovery Versus Height Bottom: Histogram of Mean Wind Speed Differences.

To address the second question, we compared the mean wind speed measured by the Triton to that measured by the met tower at the exact same set of valid time points, over the entire period of measurement for each pair (ranging from 4-25 weeks). The distribution of the differences in mean wind speed (Triton minus met tower), as a percent of the met tower-measured mean wind speed, at all 100 sensor heights on the 30 met towers, is shown in the lower panel of Figure 4. The distribution is approximately normal, with the mean of the distribution very close to zero, meaning that the Triton is, on average, unbiased with respect to met tower-mounted cup anemometers. The width of the distribution, as represented by the root mean square of the differences (RMSD), is 1.27%.

It is important to realize that these errors arise from inaccuracies in both the met towers and Tritons. If the met tower accuracy with respect to "truth" (expressed as a root mean-squared error, or RMSE) is around 1.0%, which is a reasonable assumption, then a RMSD of 1.27% is consistent with the Triton also having a RMSE of around 1.0%, assuming independent errors of the Tritons and their collocated met towers. Thus, these results show that in terms of mean wind speed, the uncertainty of Triton SoDARs (around 1%) is about the same as that of well-constructed met towers.

The Triton in India

The Indian wind energy industry is taking a keen interest in remote sensing technology, and, in particular, in the advantages offered by SoDAR technology (as described above). As with other regional markets that have explored the use of SoDAR, the same questions regarding data recovery and accuracy are frequently raised. Of particular concern is whether the SoDAR performs well during India's windiest season, the southwest monsoon, when rainfall is also maximized.

We obtained data for two collocated Tritons and met towers, one in Tamil Nadu (hereafter "Triton A"), with a 120m collocated met tower, and measurements during all of 2015; and one in Maharashtra (hereafter "Triton B"), with an 85m collocated met tower, and measurements from July-August 2017. To illustrate the behavior of the Triton measurements and the relative ease of the QC process, Figure 5 shows scatter plots of the Triton speed measurement (y-axis) versus the met tower speed measurement (x-axis), at sensor heights of 90 and 85m, respectively, for Triton A (left) and B (right). Regardless of the strength or quality of a particular 10-minute Triton measurement, a derived wind speed and direction are always recorded (except in rare instances of hardware or communication issues). The top row shows the scatter between the Triton and tower when no Triton QC is performed, i.e., when all Triton data is included regardless of quality. Particularly for Triton A, there are clearly many outliers in the 10-minute wind speeds that have not undergone QC. Some outliers (though not as many) also appear in the Triton B scatter plot with no QC. Table 2 shows statistical results, and again it is clear that Triton A's result is adversely affected by low-quality data, with a high bias and low R^2.

Triton's wind measurements are accompanied by other variables and parameters that can be used to filter the data with simple threshold algorithms. One parameter is appropriately named the "quality factor" (QF), ranging from 0 to 100, and is self-assessed by the Triton firmware, based on signal-to-noise ratio and the detection of background sound interference. We recommend removing all data for which QF $<$ 90. Another such parameter is the measured Doppler vertical velocity (VV), which indicates likely rainfall if it is large and negative. Large positive values also indicate a poor wind retrieval. We recommend removing all data for which $|VV| > 1.5$ m s^{-1}. These two filters comprise the most common method of carrying out QC for the Triton data.

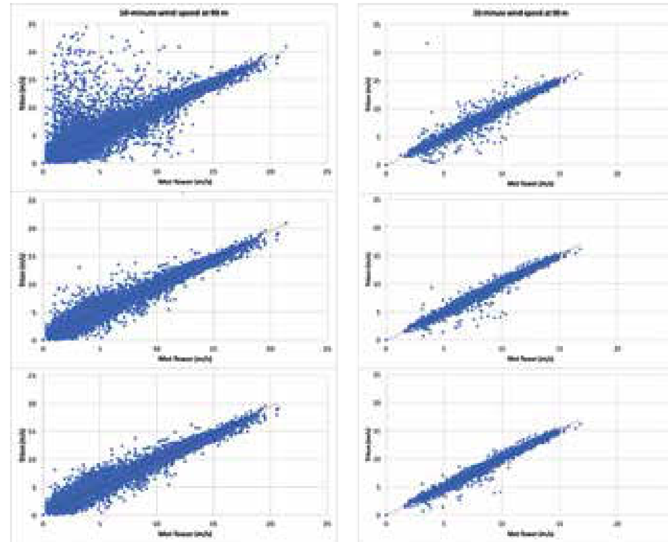

Figure 5: Comparison of two Tritons in India with Collocated Met Towers, with Three Different Levels of QC on Triton Data:

Top: No QC. Middle: Quality Factor and Vertical Velocity Threshold QC. Bottom: QF, VV, and 10-minute Ramp Threshold QC.

Triton A Quality Control	10-minute R^2	Bias (%)	Data Recovery (%)
No QC	0.88	+2.0	99.0
QF Threshold and Vertical Velocity Threshold	0.96	+0.2	90.6
QF and VV Thresholds, and Ramp Threshold	0.97	+0.2	90.0

Triton B Quality Control	10-minute R^2	Bias (%)	Data Recovery (%)
No QC	0.95	+0.6	99.9
QF Threshold and Vertical Velocity Threshold	0.97	+0.6	96.6
QF and VV Thresholds, and Ramp Threshold	0.98	+0.6	95.1

Table 2: Statistical results for each level of Triton data QC shown in Figure 5

The second row in Figure 5 shows scatter plots after the QF and VV thresholding is applied. For Triton A, most of the bias disappears, and the R^2 value increases substantially (0.88 to 0.96). There is a loss of data, of course, and in the case of Triton A, the data recovery drops to 90.6%, lower than the global average for 90m height in Fig. 5, but still a highly useful percentage of recovered data. For Triton B, the R^2 with no QC is already quite high (0.95), but increases even more (to 0.97) with standard thresholding, with very little loss of data recovery (still at 96.6%). Bias was small and remains so after thresholding. Note that Triton B's measurement period is entirely during the monsoon, so the occurrence of rainfall was either infrequent enough, or light enough in intensity, or both, as to not significantly reduce data recovery.

The third row explores one of several lesser used, but still easy to apply and potentially helpful QC methods. Here, consecutive Triton time points are compared, and if the difference (or "wind ramp") is larger in magnitude than some threshold (we used 5 m/s for Triton A, and 3 m/s for Triton B), then both time points are flagged for removal. This filtering removes single time step spikes in data that are not accurate. The lower row of scatter plots shows that this additional filtering "cleans up" the data even more compared to the met tower, with even better statistics, but at some cost to data recovery. In general, we recommend the QF/VV filters described above, but users are provided with flexibility to filter with different methods and/or thresholds to achieve their own level of comfort with the data, weighed against the value of data recovery.

Upper-Level Wind Shear

An attractive aspect of remote sensing is its ability to "see" winds at much higher altitudes than the heights of typical met towers. This is important because typical industry-standard assessment methodologies involve extrapolation of met tower measurements up to hub height (or rotor tip height). In so doing, one assumes that the wind shear profile measured over the range covered by the tower continues above the tower, but this is often not the case. Remote sensing can potentially reduce the uncertainty incurred by vertical extrapolation. The met tower collocated with Triton A is 120m in height, so this Triton/met tower pair can be used to explore two questions. First, at this site, is the shear above a typical tower height (which we'll take to be 90m) the same as the shear below that height? And, second, if they are not the same, does the Triton accurately capture this difference?

To answer these questions, we calculated the power-law shear parameter in the layers 60-90m, and 90-120m, from both the Triton and met tower measurements, at every 10-minute time point available for Triton A and its met tower. Histograms of those shear parameters are shown in Figure 6. The answer to the first question is clearly "no": looking first at only the met tower distributions (cyan-colored histograms), both the shapes of the shear distributions at the two heights, as well as the mean values, are different. The upper layer's distribution is wider and has a more pronounced double peak. It is also farther to the left, consistent with the lower mean shear (0.16 versus 0.23 in lower layer). Turning to the Triton-measured histograms (orange), these show that the answer to the second question is "yes": Triton is capturing the narrower, left-shifted, double-peaked upper layer distribution; and the two Triton-derived mean shear parameters of 0.16 and 0.22 are only slightly different than those derived from the met tower.

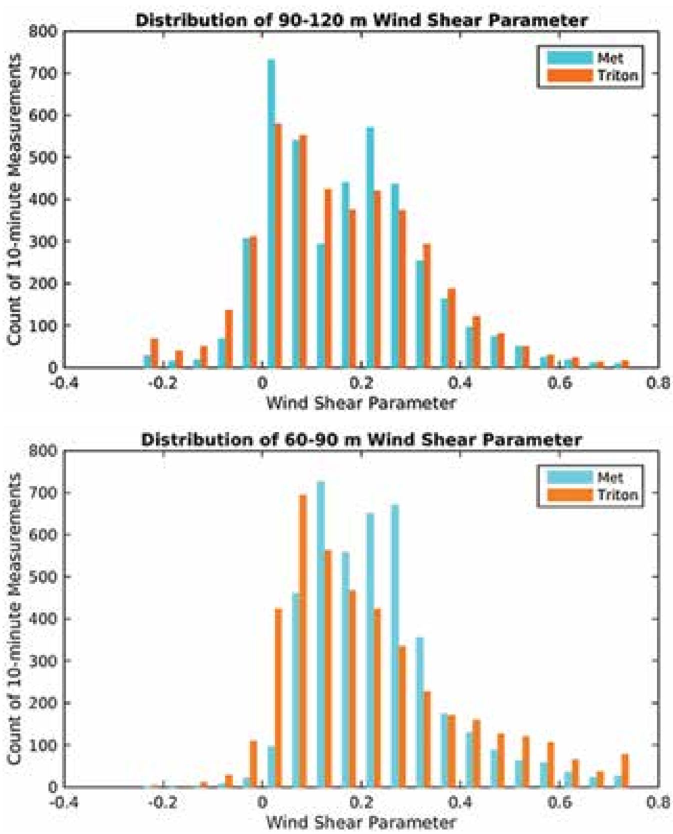

Figure 6: Distribution of 10-minute shear parameter measured by Triton A and the collocated met tower, for the lower layer (60-90 m, lower panel), and upper layer (90-120 m, upper panel)

Conclusions

The Triton Wind Profiler, a SoDAR-based remote sensing device that measures wind speed and direction up to 200 m above the ground level, has been validated in comparison to collocated met towers, both in India and across the globe.

The global validation study results indicated that, on average, Triton achieves very high data recovery at typical hub heights, and its accuracy in measuring the mean wind speed is around 1% root mean-squared error, comparable to well-constructed met towers. In addition, two Tritons deployed in India were studied in comparison to collocated met towers. The relative ease of quality controlling the Triton data was demonstrated, with significant effectiveness and improvement of statistical properties, at only a small cost in data recovery.

Furthermore, Triton performed very well during the southwest monsoon season. Data recovery seemed to suffer only very modestly from the rainfall that occurs in that season. Finally, comparisons of shear parameters measured at an upper and lower layer from both the tall tower in Tamil Nadu and the collocated Triton indicated that, at this site (and likely others as well), shear can change significantly at heights above typical met tower tops, and Triton performs well at capturing those different shear patterns at the upper heights. Overall, the results presented here engender confidence in the use of SoDAR-based remote sensing in the Indian wind industry, and should help pave the way for greater acceptance of this technology.

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Materials-based Prognostic Model for Wind Turbine Drive System Life Prediction and Life Extension


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Executive Summary

Existing condition monitoring systems can examine the current state of wind turbine drive system, but cannot provide solution for life extension or efficiency improvements. Sentient developed drive system loads and life prediction models under various Department of Defense (DOD) and Department of Energy (DOE) funded R&D programs with the goal to predict fatigue crack nucleation and propagation in main bearing and gearbox components. This research lead to the development of materials-based prognostic life prediction technology. This simulation tool considers wind loads, multi-body dynamic effects, operating conditions, lubrication effects, surface treatments (black oxide and diamond like carbon coatings), and manufacturing process-microstructure-property relationship. The benefits of this technology include drive system life prediction, life extension, safe operation, and reduction in O&M costs. This paper includes details on prognostic model development and demonstration.

1. Prognostic Modeling Approach

In the past few years, wind turbine operators have seen significant increase in O&M costs due to premature failure of main bearings and gearboxes. The major cause of gearbox failures is associated with bearings followed by gears [1], [2]. According to wind and water power technologies office gearbox failure database, 70% bearings, 26% gears and others 4% were the dominant factors for gearbox failures [3]. Among bearings, highest failures were observed in high-speed shaft(HSS) or intermediate shaft bearings (IMS) [3], [4]. It is well known that the main source of premature gearbox failures is associated with bearings but the source of these failures has not yet been accurately determined to schedule preventive maintenance. As a result, wind farm operators must evaluate the asset risk of their turbines considering the average cost $300k for replacing a gearbox. This means wind farm operators can incur O&M costs ranging in the millions of dollars.

Sentient developed a materials-based prognostic life prediction tool to perform full gearbox system-level analysis, and predict crack nucleation, lifetime and reliability of bearing and gears in service loading conditions (Figure 1). This technology includes computational material modeling to predict microstructural effects on gearbox components performance. The material models relate

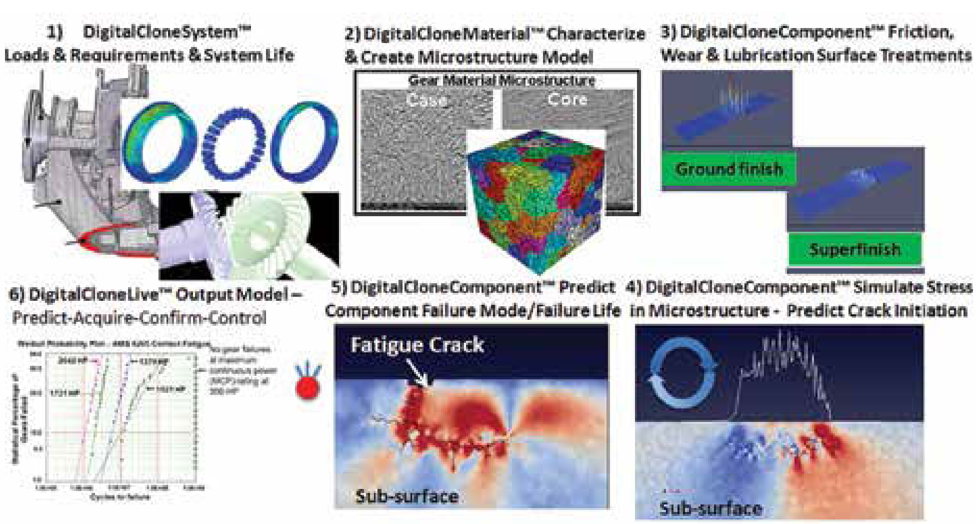

Figure 1: Sentient's micro structure-based component life prediction approach. Identified critical components and stress regions in a full wind turbine gearbox system (Step 1) and generated microstructure model (Step 2) and traction profile (Step 3) based on the gearbox operating conditions. The stresses acting on the microstructure (Step 4) during single mesh cycle were used to determine how and where damage initiates (Step 5) in the microstructure and predict fatigue life distribution (Step 6)

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the bulk material properties to microstructure. These micro and macro properties were used to predict damage accumulation and crack growth in materials under realistic wind operating conditions. This prognostic technology supports the goals of United States Integrated Computational Materials Engineering (ICME) and the Materials Genome Initiative (MGI). This paper will include details on the innovative prognostic modeling technical approach, accuracy of the models and demonstration by comparing the simulation results with wind turbine operators physical test data.

The prognostic technology is also being applied to predict and compare the performance of conventional bearings with advanced bearings (black oxide and DLC). Bearing manufacturers and operator are considering advanced bearings with engineered surfaces to improve the life. Although the research on new coatings is currently in progress[5] but Black Oxide (BO) and DLC are being applied across the wind industry to reduce maintenance and increase reliability of main bearings and gearboxes [6], [7]. This paper will also include research and findings on advanced bearing fatigue performance under realistic wind operating conditions.

Identified critical components and stress regions in a full wind turbine drive system (Step 1) and generated microstructure model (Step 2) and traction profile (Step 3) based on operating conditions. The stresses acting on the Micro-structure (Step 4) during single mesh cycle were used to determine how and where damage initiates (Step 5) in the microstructure and predict fatigue life distribution (Step 6).

2. Prognostic Model Demonstration

Prognostic model was demonstrated on wind turbine gearboxes containing conventional bearings (case hardened and through hardened) and advanced bearings (BO and DLC). Black oxide coating is applied on both the raceways and rolling elements whereas DLC is applied only to the rolling elements. The type of coating that would be most beneficial to an operator's wind farm location depends on the types of operating conditions at each site. Prognostics uses materials-based computational testing to create a digital model of each specific asset drives system at the site and predict the life of the individual bearings and gears in their current operating condition and determine (1) most critical components and (2) how long the components will last by taking into consideration components geometry, lubricant properties, and mechanical and microstructural properties.

In one case study, prognostic model was demonstrated by evaluating the performance of a particular type of coating on 1.5 MW turbine gearbox high speed shaft (HSS) bearing. At maximum power output, the coated HSS bearing contact fatigue life was improved by a factor of 4.4 compared to the uncoated bearing.

Prognostic model was also demonstrated by studying the impact of bearing quality on gearbox life. Prognostic model was applied on wind turbine gearboxes containing (1) high quality (2) medium quality and (3) low quality bearings. Gearbox field failures were attributed to low quality and medium quality bearings. Prognostic model was used to develop microstructure material models for these three bearings and simulated the gearbox wind loading conditions. This evaluation consisted of virtual simulation of the actual dynamic loads. Prognostic model then used microstructure based probabilistic life prediction methodology, as explained in Figure 1 to conduct multiple virtual tests to predict the probability of wind turbine gearbox fleet fatigue failures over a wide range of service loads.

Figure 2 and Figure 3 summarize the results of the wind turbine field failure observations and the prognostic model simulations. Simulation results indicated that the subsurface crack nucleation and micro-pits formation on the low quality and medium quality bearing inner race (Figure 2) eventually resulted in material loss, in agreement with field observations. The cracks coalesce to result in flaking of the roller path. The bearing begins operating in a clearance condition, which results in gear mesh misalignment, and allows the low speed pinion's to move forward axially and overall gearbox failure.

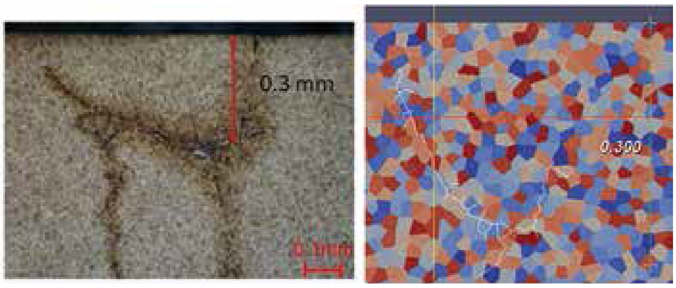

Figure 2: Prognostic Model Predicted Wind Turbine Gearbox Bearing Fatigue Damage Type (Spallation), Subsurface Crack Initiation Location, Damage Propagation Behavior and Spall Size Matches with Field Observations

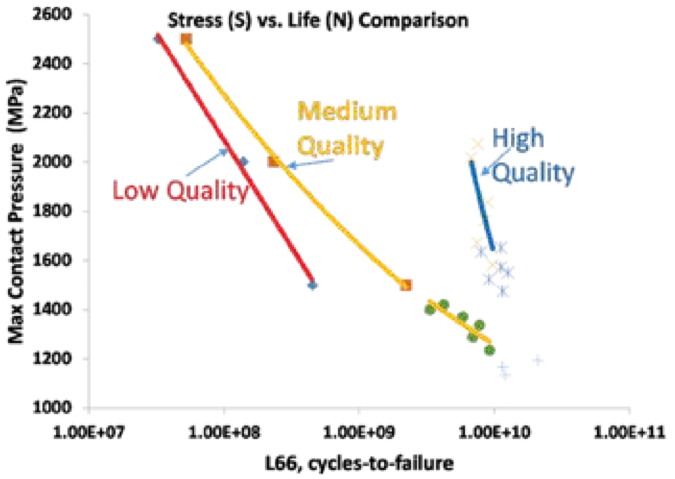

Figure 3: Prognostic Model Predictions showing the Effect of Bearing Quality on RCF Life

Prognostic model can be used to extend gearbox life of a wind turbine as shown in Figure 4. The graph on the left shows the current failure rate for wind turbines from three bearing OEMs

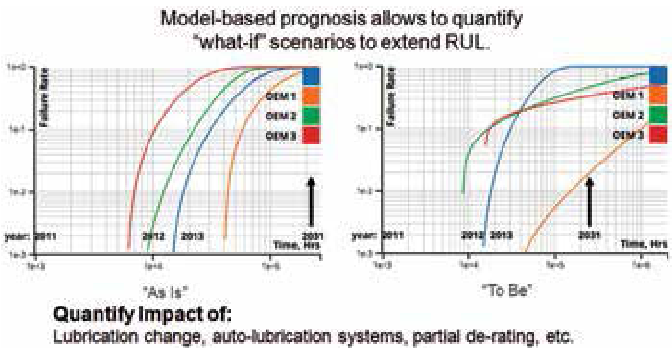

Figure 4: Gearbox life can be significantly extended through using materials-based prognostics

that typically will last between 7 and 20 years. Life extension by a factor 3 can be achieved by taking preventive actions, including (1) uptower replacements, (2) change in lubricant, and (3) derating.

Summary

Materials-based prognostic technology enables rapid assessment of the durability of wind turbine main bearing and gearbox components and systems and reduces time-consuming analysis and expensive testing currently required for these analyses. In addition, this technology can be used to accelerate the discovery and commercialization of new bearing/gear materials and systems.

Advanced prognostics provides notification that a component has early crack initiation far ahead of sensors from CBM and SCADA detection systems. This allows operators time to plan their maintenance schedules and make decisions on the type of bearing and bearing coating to use in the exchange. Prognostic model can then simulate the impact that each supplier offering would have on the life of the drive system and assist the operator in choosing which bearing replacement to use. Also, prognostic model can be used to extend gearbox life by implementing preventive measures, such as uptower replacements, de-rating and surface treatments.

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Inter-State Transmission Charges Waived for Wind and Solar Projects

Ministry of Power, Government of India has issued the Order dated 13th February 2018 about waiver of inter-state transmission charges and losses on transmission of electricity generated from solar and wind resources under para 6.4(6) of the revised tariff policy 2016 as follows (gist):

In supersession of Ministry of Power's earlier order No. 23/12/2016-R&R dated 30th September 2016 and order No. 23/12/2016-R&R dated 14th June 2017, it is hereby notified that –

1. For generation projects based on solar and wind resources, no interstate transmission charges and losses will be levied on transmission of the electricity through the inter-state transmission system for sale of power by such projects commissioned till 31st March 2022.
2. Provided that the above waiver will be available for a period of 25 years from the date of commissioning of such projects.
3. Provided further that the above waiver will be available for solar and wind projects entering into PPAs with all entities, including Distribution Companies, for sale of power from solar and wind power projects for compliance of their renewable purchase obligation.
4. Provided further that the above waiver will be allowed only to those solar and wind projects that are awarded through competitive bidding process in accordance with the guidelines issued by Central Government.

Geo Tagging (On Line Registry) of Wind Turbines

National Institute of Wind Energy is starting an online portal for generating the unique identification number for managing the registration process of the wind turbines.

Driving Innovation While Managing Risks: A Balanced Risk Management Approach for Wind Industry

Pranshu Saxena, Technical Lead, Reliability,
LM Wind Power Technologies Pvt. Ltd.

1. Introduction

With the change in the process of determination of wind-power tariffs and abundant supply of other renewable energy sources (solar energy etc.), the wind industry is facing an uncertain environment in India. The tariff crash coupled with uncertain auction policies have led to slow-down in the demand and if the situation persists would lead to lowered expectations of return on investments.

This present scenario for the wind industry remains dynamic and industry looks at innovative solutions in the products design and components. Solutions are being sought through internal Research and Development (R&D) and this is predicted to see a lot more traction in the time to come. Evident of the significance of innovations, the organizations will prioritize significant amount on R&D to launch innovative products as well as improved existing designs. The biggest motivation for the organizations is to create value for the eco-system and remain competitive in the wind industry. Nevertheless, ensure that the business emerges as a winner out of the turbulence. Unlike other industries, innovation in product design and component would remain a single determining factor for any successful business in this industry.

However, on this journey of developing and launching innovative products and components, the organization would be inevitably exposed to the grave risks due to the increase in the liabilities. The risks due to the innovative products/components are higher as they have not only been exposed to a limited testing environment but also face unforeseen operational challenges. The high uncertainty due to the risks posed the need for increased warranty reserves is required. The high reserve of warranty costs is detrimental to the competitiveness of the business in the industry. The risk would be on losing out on all fronts.

Furthermore, the business decisions connected to technology/ product/ component development in wind industry thus remains challenging and arduous due to the high capital investment involved in Research and Development (R&D) and low Return on Innovation (RoI) - due to risks involved, hence the probability of success of such projects remains highly uncertain.

Hence, this brings forth the challenge for the organizations to bring a balanced approach for driving innovations by leveraging the R&D capabilities, at the same time managing risks due to new technologies and being a profitable business.

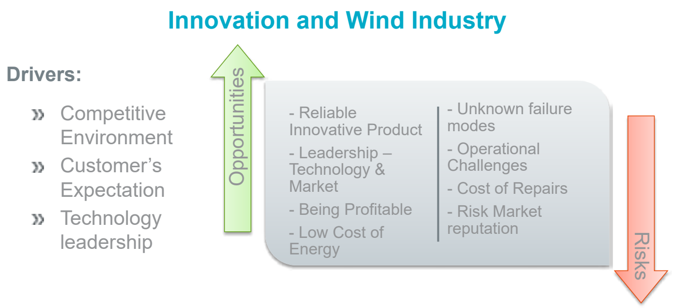

Figure 1: Technological Innovation essentially to be designed with built-in reliability at the same time managing the risks due to uncertainties.

2. Understanding Business Scenarios & Opportunities

Presently, the wind industry faces serious challenges due to crashed tariffs and the direct competition from other abundant sources, coupled with an uncertain business environment. Although, the desire of being a technology leader in the industry has always been the motivating force for innovation, the present slowdown of the demand at one end while rising investor's expectation of return on investment seems to be edged against the business. Hence, this leads to inevitable and compelling search of innovative solutions as a response. Hence, strategy of innovation has become a necessity rather than being only a desirous trait.

Strategically capitalizing on this opportunity would lead to the technological leadership in the market by developing reliable innovative products. Profitability can be reaped from the favorable market leadership position if exploited well. Overall, innovation would be an essential driver of economic progress that would benefit customers with competitive cost of power per unit, businesses with favorable cost of power generation and a healthy eco-system. Grabbing this opportunity of developing strategy for innovation would give a head-start for the business against the competition

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LM WIND POWER

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3. Risks Involved

However, the bigger opportunities also mean that the risk due to pitfalls also increases. The risk due to the innovative products/components are higher as they would be exposed to limited testing environment compelled due to shorter time to launch. Also, the face unforeseen operational condition remains a challenge for the innovative product. The pitfalls such as unknown failure modes coupled with unknown operating challenges could lead to humongous cost of repairs and financial burden for the business. And in worst case could even have serious repercussion on market reputation. In financial terms, the high uncertainty would lead to increased warranty reserves. The high reserve of warranty costs brings down the bottom line and eventually, defeats the very own purpose of the journey started with innovation.

Hence, this brings forth the challenge for the organizations to bring a balanced approach for driving innovations by leveraging the R&D capabilities, at the same time managing risks due to new technologies and ensuring a healthy bottom line.

4. Risks Apportionment Methods

Initially, the risk profile of a product is to be benchmarked. The technical risks for a product are defined by the failure rate of the product. With a strong data availability and cutting edge analytical model puts LM Wind Power ahead of the competition. Some of the well known methods available to do the benchmarking are as follows:

A. Equal Apportionment

This is the simplest method of all for allocating failure rate by distributing the target failure rate equally among all sub-systems. The weakness of this method is that subsystem goals are not assigned in accordance with the degree of difficulty associated with realization of allocated failure rate.

B. ARINC method

This method assumes that failure rates of the subsystems are known. These rates can be obtained from either existing failure data or failure rate prediction standards. This method reduces subsystem failure rates by equal percentages such that the failure rate goal is reached. The rationale behind the ARINC method is that it requires equal effort to reduce failure rates by an equal percentage of failure rates.

C. AGREE Method

This method takes into consideration subsystem complexity, mission time, and importance. Equal effective failure consequences are allocated to all elements. When the importance of all elements is the same, the AGREE method allocates equal effective failure rates for all elements.

The applied method used for the risk benchmarking is Feasibility of Objectives. This method takes into account the following parameters that provide an inclusive pragmatic approach to risk benchmarking:

a) Complexity

b) Criticality

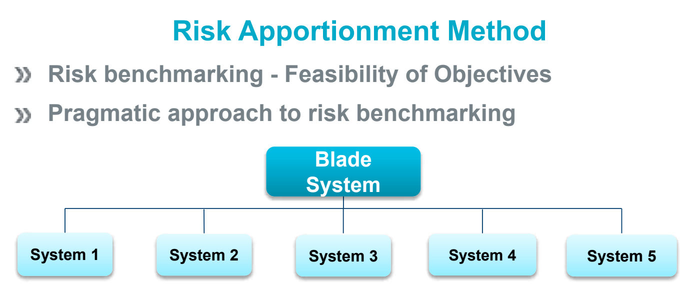
c) State of Art

d) Cost

e) Duty Cycle

A transfer function that deals with the above parameters is developed to come up for the factor that gives proportional distribution to the components. The product functionality is sub-divided into sub-system functionality and each of the sub-system is rated on the above parameters. Using the described factor a weightage factor can be derived for each of the sub-system. The weightage factor is then used as risk apportionment of the product level risks to the sub-system level risks.

This benchmarking process develops a mathematical model that apportions the product risks to the subs-system risks based on the chosen parameters.



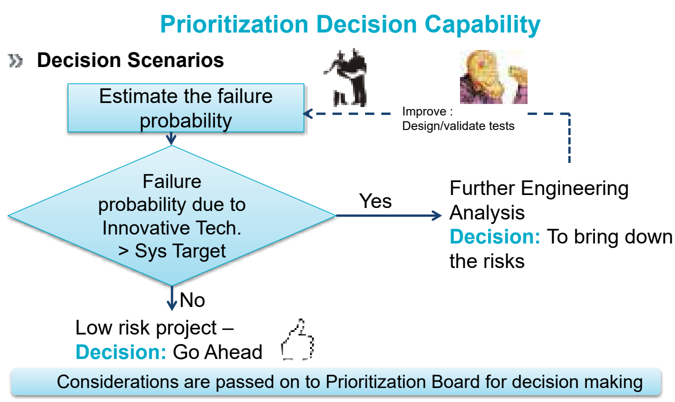
5. Outcome

The risk apportionment method described above is used to drill down the product level failure rate to the sub-system. With the sub-system targets, the benchmark threshold failure rate for each sub-system is defined.

Usually, when a new technology/component is being introduced, it affects the failure rate of one or two sub-systems in the existing product. The effect of the change is quantified in terms of failure rate. The failure rate is than compared.

Based on target comparison, the considerations to drive further test analysis (proving robustness to bring down the failure rate), further design improvements or project with engineering recommendations are passed on to prioritization board to make further decision.

The quantified approach of driving the innovations along with managing risks proves strong decision basis for the Prioritization Board. The flowchart below explains through the iterative process in decision making.



6. Conclusions

In a rapidly changing business environment and cut through competition, the approach aptly compares the quantification of risks due to technology / component in product innovation with internal risk targets for the sub-system / product. This method of risk quantification process enhances risk management capability of an organization keeping focus on long-term sustainability and directing organization towards profitable R&D projects. This approach brings the right decision-making capability where R&D projects with tolerable risks can be focused while the high risks projects can be recommended for further improvement. With stage gate process, this risk evaluation criteria drives for minimizing the technical risks at various stages of the product development.

Finally, this focused approach in bringing the right innovative product could lead an organization to be a winner if it addresses the issue of reducing cost of energy and creating value for the wind industry eco-system at the same time balancing the risks being faced by the product.

7. Going Ahead

Effective risk management is a continuous improvement process. We foresee improvement in the prioritization process addressing the long-term sustainability. This method has capability of easy integration with the stage gate process. Further, development of the analytical function for the components would improve the decision-making process for the organization.

Note: Data/method used is for illustration purposes only without sacrificing the intent of approach presented.

Snippets on Wind Power

Power Ministers' Meet: States Agree on 24X7 Power for All, Direct Benefit Transfer

Power Minister Shri R K Singh said on 7th December 2017 that most of the states have agreed on 24X7 power for all, 90 per cent pre-paid meters and Direct Benefit Transfer (DBT) of subsidies for electricity consumers across the country. "Our vision is that we want 24X7 power for all by March 2019. Now it will be a legal obligation. After March 2019, if there is any load shedding without any reason, there will be penalties except in case of technical issues or act of God," Mr. Singh said.

It was also agreed that the (distribution) losses would be reduced to below 15 per cent by January 2019. Mr. Singh said the other issue that was discussed was cross-subsidisation, as some states have 19 slabs of tariff. The power tariff will be remodelled according to the report presented by an expert committee today. He explained that the cross-subsidy would not be more than 20 per cent (the difference between highest and lowest tariff). Tariff policy provides that cross-subsidy would be brought down to 20 per cent in the first phase. It will help in reduction of tariff for a section of consumers.

The minister also made it clear to states that any tariff decided after the bid has to be adopted and power purchase agreements have to obey because that is the law.

Source: PTI, December 07, 2017

India Reduces Expenditure on Energy Subsidies by $15.4 Billion: Study

India reduced its energy subsidies by over $15 billion (over Rs 82,000 crore) between 2014 and 2016, a new report by the International Institute of Sustainable Development (IISD), the Overseas Development Institute and ICF India said. The total value of energy subsidies from the central government has declined substantially during this period from Rs 216,408 crore ($35.8 billion) to Rs 133,841 crore ($20.4 billion). While the decline is significant, subsidies still favour fossil fuels much more than renewables.

The total subsidies to coal mining and coal-fired electricity have remained stable to a slight decline over the reviewed years and amounted to Rs 14,979 crore ($2.3 billion) in 2016. Subsidies to renewables have significantly increased from Rs 2,607 crore ($431 million) in financial year 2014 to Rs 9,310 crore ($1.4 billion) in financial year 2016. As a member of the G20, India committed in 2009 to "phase out inefficient fossil fuel subsidies that encourage wasteful consumption while providing targeted support for the poorest."

Source: IANS, December 01, 2017

Feed-In Tariffs to Stay for Smaller Wind and Solar Power Projects

MNRE has clarified that States/UTs can consider procuring power from solar and wind projects of less than the defined threshold prescribed (25MW for wind, 5MW for solar) in the Competitive Bidding guidelines through Feed-in-Tariff (FiT) to be determined by concerned State Electricity Regulatory Commissions (SERCs).

The Gazette of India - Extraordinary - Part I - Section I

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New Delhi
Dated the 8th December 2017

RESOLUTION

No. 23/54/2017 – R&R

Guidelines for Tariff Based Competitive Bidding Process for Procurement of Power from Grid Connected Wind Power Projects

1. BACKGROUND

1.1 The wind power deployment in the country started in early 90s and with the conducive policy environment provided at Central and State level this segment has achieved highest growth amongst the other renewable energy technologies. The present wind power installed capacity in the country is over 32.7 GW, providing around 9% of total installed capacity. Globally India is at the 4th position in terms of wind power installed capacity after China, USA and Germany.

1.2 The Government of India has set an ambitious target of achieving 175 GW power capacity from renewable energy resources by 2022 and out of this 60 GW is to come from wind power.

1.3 The National Institute of Wind Energy (NIWE) assessed the wind power potential in the country to be over 302 GW at 100 meter above ground level. Most of this potential exists in seven windy States namely Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Tamil Nadu.

1.4 Earlier, the wind power was being procured by the Distribution Utilities at Feed-in-Tariff (FiT) determined by the respective State Electricity Regulatory Commission (SERC). FiT coupled with various incentives provided by the Central and State Government enabled growth of the wind sector many folds since 2002. The country also has strong manufacturing base with annual capacity of around 10 GW.

1.5 One of the key objectives of the Electricity Act, 2003 is promotion of competition in the electricity sector. Section 63 of the Act provides for adoption of the tariff by the Appropriate Commission if the same has been determined through transparent process of bidding in accordance with the guidelines issued by the Central Government. The National Electricity Policy, 2005 also provides for competition in the renewable energy sector to reduce the cost. The National Tariff Policy notified on 28 January 2016 also provides for encouraging procurement of renewable power through competitive bidding to reduce the tariff.

1.6 These guidelines have been formulated for procurement of wind power through transparent process of bidding as required under Section 63 of the Act.

2. OBJECTIVES OF GUIDELINES

2.1. The objective of these Guidelines is to provide a framework for procurement of wind power through a transparent process of bidding including standardisation of the process and defining of roles and responsibilities of various stakeholders. These Guidelines aim to enable the Distribution Licensees to procure wind power at competitive rates in a cost effective manner.

3. APPLICABILITY OF GUIDELINES

3.1. These Guidelines are being issued under the provisions of Section 63 of the Electricity Act, 2003 for long-term procurement of electricity through competitive bidding process by the ‘Procurer(s)’, from grid-connected Wind Power Projects (‘WPP’) having, (a) individual size of 5 MW and above at one site with minimum bid capacity of 25 MW for intra-state projects and (b) individual size of 50 MW and above at one site with minimum bid capacity of 50 MW for inter-state projects.

Explanation:

a) **Procurer(s):** The term ‘Procurer(s)’, as the context may require, shall mean the distribution licensee(s), or their Authorized Representative, or an Intermediary Procurer.


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b) **Authorised Representative of the Procurer(s):** In cases, where the distribution licensee(s), authorize any agency to carry out the tendering/bidding process on its behalf the agency will be responsible for fulfilling all the obligations imposed on the 'Procurer(s)' during the bidding phase, in accordance with these Guidelines.

c) **Intermediary Procurer**

(i) In some cases, an intermediary, between the distribution licensee(s) and the Wind Power Generator(s) (WPG) may be required either to aggregate the wind power to be purchased from different generators and sell it to the distribution licensee(s) or to enhance the credit profile. In such cases, the 'Intermediary Procurer' is essentially a trader, buying power from the WPG(s) and selling the same to one or more distribution licensees and shall carry out the bidding as per provisions of these Guidelines.

(ii) The Intermediary Procurer shall enter into a Power Purchase Agreement (PPA) with the WPG(s) and also enter into a Power Sale Agreement (PSA) with the distribution licensee(s). The PSA shall contain the relevant provisions of the PPA on a back to back basis. The Intermediary Procurer may charge trading margin as notified by the Appropriate Commission or in the absence of such notification as mutually agreed with distribution licensee(s).

(iii) As long as the Intermediary Procurer has followed these Guidelines for procurement of wind power, the distribution licensee(s) shall be deemed to have followed these Guidelines for procurement of wind power.

3.2. Unless explicitly specified in these Guidelines, the provisions of these Guidelines shall be binding on the Procurer, Authorised Representative and Intermediary Procurer. The process to be adopted in event of any deviation proposed from these Guidelines is specified in Clause 22 of these Guidelines.

4. APPROPRIATE COMMISSION

4.1 Subject to the provisions of the Electricity Act, 2003, Appropriate Commission would be as under:

a) In case the wind power projects supplying power to Distribution licensee(s) of one State, the Appropriate Commission, for the purpose of these bidding Guidelines, shall be the State Electricity Regulatory Commission of the State where the distribution licensee(s) is located.

b) In case the wind power projects supplying power to Distribution licensee(s) of more than one State, the Appropriate Commission, for the purpose of these bidding Guidelines, shall be the Central Electricity Regulatory Commission.

c) For cases involving sale of wind power from generating companies owned or controlled by Central Government, the Appropriate Commission shall be the Central Electricity Regulatory Commission.

5. PREPARATION FOR INVITING BID AND PROJECT PREPAREDNESS

The Procurer shall meet the following conditions:

5.1. Bid Documentation:

a) Prepare the bid documents in accordance with these Guidelines and Standard Bidding Documents (SBDs) [consisting of Model Request for Selection (RfS) Document, Model PPA and PSA], notified by the Central Government, except as provided in sub clause (c) below.

b) Inform the Appropriate Commission about the initiation of the bidding process.

c) Seek approval of the Appropriate Commission for deviations, if any, in the draft RfS, draft PPA, draft PSA (if applicable) from these Guidelines and/or SBDs, in accordance with the process described in Clause 22 of these Guidelines.

i. However, till the time the SBDs are notified by the Central Government, for purpose of clarity, if the Procurer while preparing the draft RfS, draft PPA, draft PSA and other Project agreements provides detailed provisions that are consistent with the Guidelines, such detailing will not be considered as deviations from these Guidelines even though such details are not provided in the Guidelines.

ii. Further, in case of an ongoing bidding process, if the bids have already been submitted by bidders prior to the notification of these Guidelines and/or SBDs, then if there are any deviations between these Guidelines and/or the SBDs and the proposed RfS, PPA, PSA (if applicable), the RfS, PPA and the PSA shall prevail.

5.2. Site-related project preparatory activities including clearances:

In order to ensure timely commencement of supply of electricity, the bidder would be required to submit documents in respect of matters as mentioned below, as per the time schedule specified in the bidding documents:

a) Land acquisition: Identification of the 100% (hundred per cent) land at the time of bid submission and within 7 (seven) months of the execution of the PPA, submission of documents/Lease Agreement to establish possession/ right to use 100% (hundred per cent) of the required land in the name of the WPG or its Affiliate for a period not less than the complete term of PPA. In case the land is in the name of Affiliate[1], the land should be transferred in the name of WPG prior to Scheduled Commissioning Date (SCD). Wherever leasing of private land is involved, the lease should allow transfer of land to the lenders or Procurer, in case of default of the WPG.

b) No Objection Certificate (NoC)/Environmental clearance (if applicable) for the Project.

c) Forest Clearance (if applicable) for the land for the Project.

d) A letter from State Transmission Utility (STU)/Central Transmission Utility (CTU), as applicable, confirming technical feasibility of connectivity of the plant to STU/ CTU substation.

e) Any other clearances (if any), as may be legally required.

6. BID STRUCTURE

6.1. Bid Size: The bids shall be designed in terms of total wind power capacity to be procured in MW. For intra-state projects a bidder shall be allowed to bid for a minimum 25 MW wind power projects with at least 5 MW project at one site and for inter-state projects a bidder shall be allowed to bid for a minimum 50 MW wind power project at one site. The Procurer may also choose to specify the maximum capacity that can be allotted to a single bidder including its Affiliates. The maximum capacity for single bidder or company or group of companies may be fixed by the Procurer keeping in mind factors such as economies of scale, land availability, expected competition and need for development of the market.

6.2. Bidding Parameters: For procurement of wind power, the tariff quoted by the bidder shall be the bidding parameter. The Procurer may specify a benchmark tariff and in that case bidder has to quote tariff not more than benchmark tariff. The Procurer may select either of the following kinds of tariff based Bidding: (a) fixed tariff in Rs./kWh for 25 years or more or (b) escalating tariff in Rs./kWh with pre-defined quantum of annual escalations fixed in Rs./kWh and number of years from which such fixed escalation will be provided. The procurer may also opt for e-reverse auction for final selection of bidders, in such case this will be specifically mentioned in the notice inviting bids and bid document. The Procurer may disclose in the RfS, the prevailing incentives available to the WPGs.

7. POWER PURCHASE AGREEMENT

The draft PPA proposed to be entered into with the successful bidder and draft PSA (if applicable) shall be issued along with the RfS. Standard provisions to be incorporated as part of the PPA shall include *inter alia* the following, which, unless otherwise specified herein, shall be provided for on a back to back basis in the PSA:

7.1. PPA Period: As the PPA period influences the tariff by determining the period over which the investment is returned to the investor, longer PPA is favoured for lower tariffs. The PPA period should thus be not less than 25 years from the date of the SCD or from the date of full commissioning of the projects, whichever is earlier. The PPA may be further extended on such term and conditions as mutually agreed between the parties signing the PPA and approved by Appropriate Commission, provided the arrangements with the land and infrastructure owning agencies, the relevant transmission agencies and system operators permit operation of the Wind Power Project beyond the initial PPA period of 25 years.

7.2. Capacity Utilisation Factor (CUF):

7.2.1. The WPG will declare the annual CUF of its Project at the time of signing of PPA and will be allowed to revise the same once within first year of COD. Calculation of CUF will be on yearly basis from 1st April of the year to 31st March of next year. The declared annual CUF shall in no case be less than 22 percent. The variation permitted in wind power generation from the declared CUF value will be indicated in RfS. The lower limit will, however, be relaxable to the extent of non-availability of grid for evacuation of wind power, which is beyond the control of the WPG. For the first year of operation of the project, the annual CUF shall be calculated for the complete year after COD of the Project. Subsequently, the annual CUF will be calculated every year from 1st April of the year to 31st March next year.

7.2.2. In case the project supplies energy less than the energy corresponding to the minimum CUF, the WPG will be liable to pay to the Procurer, penalty for the shortfall in availability of energy. This however will be relaxable to the extent of grid non-availability for evacuation, which is beyond the control of WPG. The amount of such penalty

[1] Affiliate in relation to a company shall mean a person who controls, is controlled by, or is under the common control with such Company. The expression 'control' shall mean the ownership, directly or indirectly of more than the 50% of the voting shares of such company or right to appoint majority Directors.

will be in accordance with the terms of the PPA, which shall ensure that the Procurer is offset for all potential costs associated with low generation and supply of power under the PPA, subject to a minimum of 75% (Seventy-five per cent) of the cost of this shortfall in energy terms, calculated at PPA tariff. Penalties may be prescribed on the amount of shortfall, higher shortfall may attract higher penalties and vice-versa.

7.2.3. In case the availability of power more than the maximum CUF specified, WPG will be free to sell it to any other entity provided first right of refusal will vest with the Procurer(s). In case the Procurer purchases the excess generation, the same may be done at 75% of the PPA tariff, and provision to this effect shall be clearly indicated in the RfS document.

7.3. Repowering: The WPG will be free to re-power their plants during the PPA duration. However, the Procurer will be obliged to buy power only as per terms of PPA and any excess generation will be dealt as specified in Clause 7.2 of these Guidelines.

7.4. Payment Security: The Procurer shall provide adequate payment security measures, as specified below:

7.4.1. Scenario 1: Direct procurement by Distribution licensee from WPG:

The Distribution licensee shall provide payment security to the WPG through:

a) **Revolving Letter of Credit (LC)** of an amount not less than 1 (one) months' average billing from the Project under consideration;

AND

b) **Payment Security Fund,** which shall be suitable to support payment for at least 3 (three) months' billing of all the Projects tied up with such fund;

c) In addition to a) & b) above, the Procurer may also choose to provide **State Government Guarantee**, in a legally enforceable form, ensuring that there is adequate security to the WPG, both in terms of payment of energy charges and termination compensation if any.

7.4.2. Scenario 2: Intermediary-Procurer procures from the Wind Power Generator and sells to the Distribution licensee:

a) **Payment Security by Intermediary Procurer to the WPG:** The Intermediary Procurer shall provide payment security to the WPG through:

i. **Revolving Letter of Credit (LC)** of an amount not less than 1 (one) months' average billing from the Project under consideration;

AND

ii. **Payment Security Fund,** which shall be suitable to support payment of at least 3 (three) months' billing of all the Projects tied up with such fund.

b) **Payment Security by Distribution licensee to Intermediary Procurer:** The Distribution licensee shall provide payment security to the Intermediary Procurer through:

i. **Revolving Letter of Credit (LC)** of an amount not less than 1 (one) months' average billing from the Project(s) under consideration;

AND

ii. **State Government Guarantee,** in a legally enforceable form, such that there is adequate security, both in terms of payment of energy charges and termination compensation if any. *[for the purpose of this Clause, the Tri-Partite Agreement (TPA) signed between Reserve Bank of India, Central Government and State Government shall qualify as State Government Guarantee covering the security for payment of energy charges].* The Intermediary Procurer shall ensure that upon invoking this guarantee, it shall at once, pass on the same to the WPG, to the extent the payments to the WPG in terms of the PPA are due.

iii. In addition to i) & ii) above, the Distribution licensee may also choose to provide **Payment Security Fund,** which shall be suitable to support payment of at least 3 (three) months' billing of all the Projects tied up with such fund.

It is hereby clarified that the State Government guarantee shall be invoked only after the Intermediary Procurer has been unable to recover its dues under the PPA by means of the Letter of Credit and the Payment Security Fund, if any.

7.5. Force Majeure: The PPA shall contain provisions with regard to *force majeure* definitions, exclusions, applicability and available relief on account of *force majeure,* as per the industry standards. The WPG shall intimate the Procurer about the occurrence of *force majeure* within 15 (fifteen) days of the start of the *force majeure* and the Procurer shall take a decision on his claim within 15 days of the receipt of the intimation.

Government of India from time to time issues order for waiver of inter-state transmission system (ISTS) charges and losses on transmission of wind power till a certain date. In case the SCD of wind project is before the date till above ISTS waiver is applicable, and if the commissioning of the wind project gets delayed beyond the applicable


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date of ISTS waiver due to foce majeure event, the liability of transmission charges and losses would be shared between the WPG and procurer(s) in ratio of 50:50. However, in case the commissioning of the wind project gets delayed beyond the applicable date of ISTS waiver due to reasons attributable to the WPG the liability of transmission charges and losses would be of WPG.

7.6. **Generation Compensation for Off-take Constraints:** The Procurer may be constrained not to off-take the power scheduled by WPG on account of Grid unavailability or in the eventuality of a Back-down.

7.6.1. Generation Compensation in offtake constraints due to Grid Unavailability:

During the operation of the plant, there can be some periods where the plant can generate power but due to temporary transmission unavailability power is not evacuated, for reasons not attributable to the WPG. In such cases the generation compensation shall be addressed by the Procurer in the following manner:

Duration of Grid unavailability	Provision for Generation Compensation
Grid unavailability in a contract year as beyond 50 hours in a Contract Year as defined in the PPA:	Generation Loss = [(Average Generation per hour during the contract year) x (number of hours of grid unavailability during the contract year)] *Where, Average Generation per hour during the contract year (kWh) = Total generation in the contract year (kWh) ÷ 8766 hours less total hours of grid unavailability in a Contract year*

The excess generation by the WPG equal to this generation loss shall be procured by the Procurer at the PPA tariff so as to offset this loss in the succeeding 3 (three) Contract Years. *(Contract Year, shall be as defined in PPA.)*

As an alternative to the mechanism provided above in Clause 7.6.1, the Procurer may choose to provide Generation Compensation, in terms of PPA tariff, for the Generation loss as defined in Clause 7.6.1, and for Grid unavailability beyond 50 hours in a Contract Year as defined in the PPA.

7.6.2. Offtake constraints due to Backdown: The WPG and the Procurer shall follow the forecasting and scheduling process as per the regulations in this regard by the Appropriate Commission. The Government of India, as per Clause 5.2(u) of the Indian Electricity Grid Code (IEGC), encourages a status of 'must-run' to wind power projects. Accordingly, no wind power plant, duly commissioned, should be directed to back down by a Discom/Load Dispatch Centre (LDC). In case such eventuality of Backdown arises, except for the cases where the Backdown is on account of events like consideration of grid security or safety of any equipment or personnel or other such conditions, the WPG shall be eligible for a Generation Compensation, from the Procurer, in the manner detailed below.

Duration of Backdown	Provision for Generation Compensation
Hours of Backdown during a monthly billing cycle.	*Generation Compensation =* *50% x (Average Generation during the month corresponding to the capacity backed down) x PPA Tariff* *Where, Average Generation during the month corresponding to the capacity backed down (kWh) = (CUF during the month) x ∑ (Backed down capacity in MW x corresponding time of backdown in hours x 1000)*

The Generation Compensation as calculated above will be limited to the extent of shortfall in annual generation corresponding to the maximum CUF permitted as per Clause 7.2.1 and the same will be settled on annual basis. No Trading Margin shall be applicable on this Generation Compensation.

Possible conditions for exclusion of Generation Compensation, on account of Backdown purposes, shall be clearly specified in the RfS and the PPA.

7.7. **Event of Default and the Consequences thereof:** While detailed provisions with regard to the event of default of the concerned parties and its resulting consequences shall be detailed in the SBDs, this clause lays down the broad principles of contractually dealing with the default of the WPG and the Procurers (excluding the Intermediary Procurer).

7.7.1. Generator Event of Default and the consequences thereof:

a) In the event the generator is unable to commission the plant within the stipulated time period, or fails to supply power in terms of the PPA, or assigns or novates any of its rights or obligations contrary to the terms of the PPA, or repudiates the PPA, or effectuates a change in control or shareholding of its promoters in breach of the provisions of the PPA, or commits any other acts or omissions as laid down in the PPA and is also unable to cure any of the aforesaid within the cure period, as may be provided in the PPA; the generator shall be construed to be in default.

b) Upon being in default, the WPG shall be liable to pay to the Procurer, damages, as detailed in the PPA. The Procurer shall have the right to recover the said damages by way of forfeiture of bank guarantee, if any, without prejudice to resorting to any other legal course or remedy.

c) In addition to, the levy of damages as aforesaid, in the event of a default by the WPG, the lenders shall be entitled to exercise their rights of substitution, in accordance with substitution agreement provided in the PPA and in the procedure to be detailed in the PPA and in concurrence with the Procurer. However, in the event the lenders are unable to substitute the defaulting generator within the stipulated period, the Procurer may terminate the PPA and acquire the project assets for an amount equivalent to 90% of the debt due or less as mutually agreed, failing which, the lenders may exercise their mortgage rights and liquidate the project assets.

7.7.2. Procurer Event of Default and the Consequences thereof:

a) If the Procurer is in default on account of reasons including *inter alia* failure to pay the monthly and/or supplementary bills within the stipulated time period or repudiation of the PPA, the defaulting Procurer shall, subject to the prior consent of the WPG, novate its part of the PPA to any third party, including its Affiliates within the stipulated period.

b) In the event the aforesaid novation is not acceptable to the WPG, or if no offer of novation is made by the defaulting Procurer within the stipulated period, then the WPG may terminate the PPA and at its discretion require the defaulting Procurer to either (i) takeover the project assets by making a payment of the termination compensation equivalent to the amount of the debt due and the 150% (one hundred and fifty per cent) of the adjusted equity as detailed in the PPA or, (ii) pay to the WPG, damages, equivalent to 6 (six) months, or balance PPA period whichever is less, of charges for its contracted capacity, with the project assets being retained by the WPG.

c) In the event of termination of PPA, any damages or charges payable to the STU/CTU, for the connectivity of the plant, shall be borne by the Procurer.

7.8. Change in Law

7.8.1. In the event a change in Law results in any adverse financial loss/gain to the WPG then, in order to ensure that the WPG is placed in the same financial position as it would have been had it not been for the occurrence of the change in Law, the WPG/Procurer shall be entitled to compensation by the other party, as the case may be, subject to the condition that the quantum and mechanism of compensation payment shall be determined and shall be effective from such date as may be decided by the Appropriate Commission.

7.8.2. In these Guidelines, the term 'Change in Law' shall refer to the occurrence of the events, after the last date of the bid submission, including (i) the enactment of any new law; or (ii) an amendment, modification or repeal of an existing law; or (iii) the requirement to obtain a new consent, permit or license; or (iv) any modification to the prevailing conditions prescribed for obtaining an consent, permit or license, not owing to any default of the WPG; or (v) any change in the rates of any taxes which have a direct effect on the Project. However, Change in Law shall not include any change in (a) taxes on corporate income or any change in any withholding tax on income or dividends; and (b) Custom duty on imported equipment.

8. BIDDING PROCESS

8.1. The Procurer shall call for the bids adopting a single stage two envelop bidding process to be conducted through Electronic mode (e-bidding). The procurer may also opt for e-reverse auction for final selection of bidders, in such a case, this will be specifically mentioned in the notice inviting bids and bid document. E-procurement platforms with a successful track record and with adequate safety, security and confidentiality features will be used.

8.2. The Procurer shall invite the bidders to participate in the RfS for installation of WPP(s) in terms of these Guidelines.

8.3. The bidding documents including the RfS, draft PPA and draft PSA (if applicable) shall be prepared by the Procurer in consonance with these Guidelines and the SBDs.

8.4. The Procurer shall publish the RfS notice in at least two national newspapers and its own website to accord wide publicity.

8.5. The Procurer shall provide opportunity for pre-bid conference to the prospective bidders, and shall provide written interpretation of the bid documents to any bidder which shall also be made available to all other bidders. All the concerned parties shall rely solely on the written communication. Any clarification or revision to the bidding documents shall be uploaded on the website of the Procurer for adequate information. In the event of the issuance of any revision or amendment of the bidding documents, the bidders shall be provided a period of at least 7 (seven) days therefrom, for submission of bids.

9. RFS DOCUMENT

The standard provisions to be provided by the Procurer in the RfS shall include the following:

9.1. **Bid Responsiveness:** The bid shall be evaluated only if it is responsive and satisfies conditions including *inter-alia* ~

- bidder or any of its Affiliates is not a willful defaulter to any lender
- there is no major litigation pending or threatened against the bidder or any of its Affiliates which are of a nature that could cast a doubt on the ability or the suitability of the bidder to undertake the project

9.2. **Qualification requirements to be met by the bidders:**

9.2.1. **Technical Criteria:** The Government would like to encourage competition by way of increased participation. However, in order to ensure proper implementation of the projects, the Procurer may choose to specify technical criteria such as past experience of the bidders, timely execution of projects, etc. Such criteria should be set after an assessment of the number of project developers that are expected to meet the criteria so that an adequate level of competition is achieved. Cut-off date for meeting the technical criteria should generally be kept as the end date of the financial year that is previous to the financial year in which the bid is being floated.

9.2.2. **Financial Criteria:**

a) **Net-worth:**

(i) The Procurer shall specify financial criteria in the form of net-worth as a part of the qualification requirement. The net-worth requirement should be at least 20% of the Estimated Capital Cost for WPP for the year in which bids are invited.

(ii) The net worth to be considered for the above purpose will be the cumulative net-worth of the bidding company or consortium together with the net-worth of those Affiliates of the bidder(s) that undertake to contribute the required equity funding and performance bank guarantees in case the bidder(s) fail to do so in accordance with the RfS.

(iii) It is clarified that the net-worth to be considered for this clause will be the total net-worth as calculated in accordance with the Companies Act, 2013.

b) **Liquidity:** It is necessary that the bidder has sufficient cash flow/internal accruals/any bank reference to manage the fund requirements for the project. Accordingly, the Procurer may also stipulate suitable parameters such as annual turnover, internal resource generation, bank references/ line of credit, bidding capacity etc.

9.3. **Quantum of the Earnest Money Deposit (EMD):** Procurer will specify the quantum of the Earnest Money Deposit (EMD) in the form of a bank guarantee, to be furnished by the bidders. The EMD shall stand forfeited in the event of failure of the successful bidder to execute the PPA within the stipulated time period.

9.4. **Compliance of FDI Laws by foreign bidders:** In case a Foreign Company is selected as the successful bidder, it shall comply with all the laws and provisions related to Foreign Direct Investment in India.

10. BID SUBMISSION AND EVALUATION

10.1. Formation of consortium by bidders shall be permitted, in which case the consortium shall identify a lead member which shall be the contact point for all correspondences during the bidding process. The Procurer may specify technical and financial criteria, and lock in requirements for the lead member of the consortium.

10.2. The Procurer shall constitute committee for evaluation of the bids (Evaluation Committee), with at least three members, including at least one member with expertise in financial matters/bid evaluation.

10.3. The bidders may be required to submit non-refundable processing fee as specified in the RfS.

10.4. The bidders shall be required to submit separate technical and price bids. Bidders shall also be required to furnish necessary bid-guarantee in the form of an EMD along with the bids.

10.5. The technical bids shall be evaluated to ensure that the bids submitted meet the eligibility criteria set out in the RfS document on all evaluation parameters. Only the bids that meet the evaluation criteria set out in the RfS shall be considered for further evaluation on the price bids.

10.6. The Procurer may hold a pre bid meeting to take feedback and to clarify important aspects of the bidding process.

10.7. To ensure competitiveness, the minimum number of qualified bidders should be two. If the number of qualified bidders is less than two, even after three attempts of bidding, and the Procurer still wants to continue with the bidding process, the same may be done with the consent of the Appropriate Commission.

10.8. The price bid shall be rejected, if it contains any deviation from the bid conditions. No clarifications shall normally be requested from bidders at this stage.

10.9. **Bid evaluation methodology:** The comparison of bids shall be on the basis of the bidding criteria as specified in the RfS, i.e. the fixed tariff in Rs./kWh for 25 years or

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Aim---Providing reliable, excellent quality products and service to the esteemed wind market customers.

Target---Have a better future for next generations by providing more contribution to the green energy worldwide.

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more, as the case may be; or the first year tariff in Rs./kWh in case of escalating tariff in Rs./kWh with pre defined quantum of annual escalations fixed in Rs./kWh and number of years from which such fixed escalation will be provided. Ranking of the bidders will start from the bidder quoting the 'lowest tariff (L1)'.

10.10. The detailed procedure for evaluation of the bid and selection of the bidder shall be provided for in the RfS.

11. INDICATIVE TIME TABLE FOR BID PROCESS

11.1. In the bidding process, a minimum period of 30 (thirty) days shall be allowed between the issuance of RfS documents and the last date of bid submission. The indicative time table for the bidding process is as below.

Time Table for Bid Process

Event	Time from Zero date
Date of issue of RfS and draft PPA and PSA (if applicable)	Zero date
Bid clarification, conferences, revision of RfS, etc.	**
Rfs bid submission	30 - 45 days
Evaluation of bids and issue of Letter of Award	75 days
Signing of PPA	105 days

** In case of any change in RfS document, the Procurer shall provide Bidders additional time in accordance with Clause 8.5 of these Guidelines.

Note: It is clarified that if the Procurer gives extended time for any of the events in the bidding process, on account of delay in achieving the activities required to be completed before the event, such extension of time shall not in any way be deviation from these Guidelines.

11.2. In normal circumstances, the bidding process is likely to be completed in a period of 120 (one hundred and twenty) days.

12. CONTRACT AWARD AND CONCLUSION

12.1. The PPA shall be signed with the successful Bidder/Project Company or an SPV formed by the successful Bidder.

12.2. After the conclusion of bidding process, the Evaluation Committee constituted for evaluation of RfS bids shall critically evaluate the bids and certify as appropriate that the bidding process and the evaluation has been conducted in conformity to the provisions of the RfS.

12.3. For the purpose of transparency, the Procurer shall after the execution of PPA publicly disclose the name(s) of the successful Bidder(s) and the tariff quoted by them together with breakup into components, if any. The public disclosure shall be made by posting the requisite details on the website of the Procurer for at least 30 (thirty) days.

12.4. Subject to provisions of the Act, the distribution licensee or the intermediary procurer as the case may be, shall approach the Appropriate Commission for adoption of tariffs by the Appropriate Commission in terms of Section 63 of the Act.

13. BANK GUARANTEES

The WPG shall provide the following bank guarantees to the Procurer in terms of the RfS and the PPA:

13.1. Earnest Money Deposit (EMD) to be fixed by the Procurer [but not to be more than 5% (five percent) of the Estimated Capital Cost for wind power project for the financial year in which the bids are invited] to be submitted in the form of a bank guarantee along with response to RfS.

13.2. Performance Bank Guarantee (PBG) to be fixed by the Procurer [but not to be more than 2% (two percent) of the Estimated Capital Cost for wind power project for the financial year in which the bids are invited] to be submitted at the time of signing of the PPA. In addition to the other remedies, this PBG can be encashed to recover any damages/dues of the WPG in terms of the PPA. It is hereby clarified that the damages/dues recovered by the Intermediary Procurer by encashing the PBG, upon the default of the WPG under the PPA, shall be passed on by the Intermediary Procurer to the distribution licensee(s) in terms of the PSA.

14. FINANCIAL CLOSURE

14.1. The WPG shall attain the financial closure in terms of the PPA, within 7 (seven) months from the date of execution of the Power Purchase Agreement.

14.2. Failing the aforesaid, the Procurer shall encash the PBG unless the delay is on account of *force majeure.* An extension for the attainment of the financial closure can however be considered by the Procurer, on the sole request of the WPG, on payment of a penalty as specified in the PPA. This extension will not have any impact on the SCD. Any penalty paid so, shall be returned to the WPG without any interest on achievement of successful commissioning within the SCD.

15. MINIMUM PAID UP SHARE CAPITAL TO BE HELD BY THE PROMOTER

15.1. The successful bidder, if being a single company, shall ensure that its shareholding in the SPV/project company executing the PPA shall not fall below 51% at any time prior to 1 (one) year from the COD (as defined in Clause 17), except with the prior approval of the Procurer. In the event the successful bidder is a consortium, then the combined shareholding of the consortium members in the SPV/ project company executing the PPA, shall not fall below 51% at any time prior to 1 (one) year from the COD, except with the prior approval of the Procurer. However, in case the successful bidder shall be itself executing the PPA, then it shall ensure that its promoters shall not cede control[2] till 1 (one) year from the COD, except with the prior approval of the Procurer. In this case, it shall also be essential that the successful bidder shall provide the information about its promoters and their shareholding to the Procurer before signing of the PPA with Procurer.

15.2. Any change in the shareholding after the expiry of 1 (one) year from the COD can be undertaken under intimation to Procurer.

15.3. In the event the WPG is in default to the lender(s), lenders shall be entitled to undertake **'Substitution of Promoter'** in concurrence with the Procurers.

16. COMMISSIONING

16.1. Part Commissioning: Part commissioning of the Project shall be accepted by Procurer subject to the condition that the Minimum Capacity for acceptance of first part commissioning shall be 50% of Project Capacity or 50M, whichever is lower, without prejudice to the imposition of penalty, in terms of the PPA on the part which is not commissioned. However, in case of inter-state project, minimum capacity for acceptance of first part commissioning shall be at least 50 MW. A project of capacity 100 MW or less can be commissioned in maximum two parts. The project with capacity with more than 100 MW can be commissioned in parts of at least 50 MW each with last part could be the balance capacity. However, the SCD will not get altered due to part-commissioning. Irrespective of dates of part commissioning, the PPA will remain in force for a period of 25 years from the SCD or from the date of full commissioning of the projects, whichever is earlier.

16.2. Early Commissioning: The WPG shall be permitted for full commissioning as well as part commissioning of the Project even prior to the SCD subject to availability of transmission connectivity and Long Term Access (LTA). In cases of early part commissioning, till the achievement of full commissioning or SCD, whichever is earlier, the Procurer may purchase the generation, at 75% (seventy-five per cent) of the PPA tariff.

2 The expression 'control' shall mean the ownership, directly or indirectly, of more than 50% of the voting shares of such Company or right to appoint majority Directors.

16.3. Commissioning Schedule: The Projects shall be commissioned within a period of 18 (eighteen) months from the date of execution of the PPA. However, if for some reasons, the scheduled commissioning period needs to be kept higher than that provided in these guidelines, the Procurer can do the same at his end. Delay in commissioning, beyond the SCD shall involve penalties on the WPG, as detailed out in PPA.

17. COMMERCIAL OPERATION DATE (COD)

The Commercial Operation Date (COD) shall be considered as the actual date of commissioning of the project as declared by the Commissioning Committee constituted by SNA. In case of part commissioning COD will be declared only for the part of the project capacity.

18. TRANSMISSION CONNECTIVITY

18.1. The WPP shall be designed for inter-connection with STU/CTU substation either directly or from pooling station where other projects also connected, through a dedicated transmission line at the appropriate voltage level, as may be specified by the Procurer.

18.2. The responsibility of getting Transmission Connectivity and LTA to the transmission system owned by the STU/ CTU will lie entirely with the WPG and shall be at the cost of WPG.

18.3. The Inter-connection/Metering Point, is the point at which energy supplied to the Procurer shall be measured, shall be the bus bar of the STU/CTU substation at which the wind power is injected in the transmission system of STU/CTU. For interconnection with grid and metering, the WPG shall abide by applicable Grid Code, Grid Connectivity Standards, Regulation on Communication System for transmission of electricity and other regulations (as amended from time to time) issued by Appropriate Commission and CEA. The transmission of power up to the point of interconnection where the metering is done for energy accounting shall be the responsibility of the WPG at his own cost. All expenses including transmission charges (if any) and losses in relation to the transmission beyond the Metering Point shall be borne by the Procurer(s) except as provided under Clause 7.5.

18.4. The WPGs shall comply CERC/SERC regulations on Forecasting, Scheduling and Deviation Settlement, as applicable and are responsible for all liabilities related to LTA and Connectivity.

18.5. The transmission connectivity to the WPG may be provided by the CTU/STU, as the case may be, prior to commissioning of the project on the request of the project developer, to facilitate testing and allow flow of infirm power generated into the grid to avoid wastage of Power.

19. TECHNICAL SPECIFICATIONS

Procurers shall promote commercially established and operational technologies to minimize the technology risk and to achieve the timely commissioning of the Projects. In order to ensure quality of wind turbines installed, only type certified wind turbine models listed in Revised List of Models and Manufactures (RLMM) brought out by MNRE from time to time, will be allowed for deployment in the country. The wind projects will be developed as per Guidelines issued by MNRE on Development of Onshore Wind Power Projects.

20. ROLE OF STATE NODAL AGENCIES

The State Nodal Agency appointed by respective State Government will provide necessary support to facilitate the required approvals and sanctions in a time bound manner so as to achieve commissioning of the Projects within the scheduled Timeline. This may include facilitation in the following areas:

- Coordination among various State and Central agencies for speedy implementation of projects.
- Support during commissioning of projects and constitute Commissioning Committee to verify commissioning of the projects and issue of commissioning certificates.

21. PERFORMANCE MONITORING

All wind power projects shall install necessary equipment to continuously measure wind resource data and other weather parameters and electrical parameters from each wind turbine. They are required to submit this data through online portal to National Institute of Wind energy for monitoring the performance for the entire life of wind turbine.

22. DEVIATION FROM PROCESS DEFINED IN THE GUIDELINES

In case there is any deviation from these Guidelines and/or the SBDs, the same shall be subject to approval by the Appropriate Commission. The Appropriate Commission shall approve or require modification to the bid documents within a reasonable time not exceeding 60 (sixty) days.

23. ARBITRATION

In the event CERC is the Appropriate Commission, any dispute arises claiming any change in or regarding determination of the tariff or any tariff related matters, or which partly or wholly could result in change in tariff, such dispute shall be adjudicated by the CERC. All other disputes shall be resolved by arbitration under the Indian Arbitration and Conciliation Act, 1996. In the event SERC is the Appropriate Commission, then all disputes shall be adjudicated by the SERC or shall be referred for arbitration by the SERC.

24. CLARIFICATION AND MODIFICATION TO GUIDELINES

If any difficulty arises in giving effect to any provision of these Guidelines or interpretation of the Guidelines or modification to the Guidelines, Ministry of New & Renewable Energy is empowered to do the same in consultation with Ministry of Power. The decision in this regard shall be binding on all the parties concerned.

S/d

(Shalini Prasad)
Additional Secretary to the Govt. of India

Snippets on Wind Power

India Presents $3.1 tn Climate Investment Opportunities till 2030: IFC

India's ambitious plans to meet its climate targets under the Paris Agreement represent about $3.1 trillion worth of investment opportunities by 2030, said in a report by the International Finance Corporation (IFC). According to IFC, a member of the World Bank Group, the sectors offering those investment opportunities are renewable energy, green buildings, transport infrastructure, electric vehicles and climate-smart agriculture. As per the IFC estimation, India's renewable energy sector that aims to install 175GW of capacity by 2022, has opportunities worth $448 billion. India aims for a 40 per cent of its installed capacity to be renewables (solar, wind, etc.) by 2030.

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Know Your Member

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Chief Executive Officer and
Managing Director of Senvion India

About SENVION GmbH

Senvion is a leading global manufacturer of onshore and offshore wind turbines. The company develops, produces and markets wind turbines for almost any location - with rated outputs of 2 MW to 6.33 MW and rotor diameters of 82 metres to 152 metres. Furthermore, the company offers its customers project specific solutions in the areas of turnkey, service and maintenance, transport and installation, as well as foundation planning and construction. The Senvion systems are mainly designed in the major TechCenters in Osterrönfeld and Bangalore and manufactured at its German and Portuguese plants in Bremerhaven, Vagos and Oliveira de Frades as well as in Żory-Warszowice, Poland and Baramati, India.

About Senvion India

Senvion Wind Technology Private Limited is the wholly owned subsidiary of Senvion GmbH, Germany with locations in the cities of Mumbai and Bangalore and an upcoming factory at Baramati in Maharashtra. The headquarter in Mumbai since 2016 focuses on providing high-quality wind energy solutions for the Indian market and coordinates all sales, project management, aftermarket service activities for the region. In Bangalore, a new Research & Development Centre was opened in September 2015 to scale up Senvion's R&D capacities. The team there is strengthening the global TechCenter based in Osterrönfeld, Germany, in further developing wind turbines in order to continue Senvion's international growth path.

Senvion has launched its most efficient 2MW class turbines with 2.XM series and it expands our range of wind turbines to cater to low winds. The 2.XM series is launched with the 2.4M110 and 2.3M120 at various hub heights up to 120 meter. The objective is to harness the wind power most effectively by deploying the right turbine depending on the wind conditions at each site.

This extremely robust wind energy platform is equipped with an integrated drive train, a variable speed electrically excited generator, a modular full converter system and an electrical pitch system.

Senvion Manufacturing Plant

IWTMA Office shifted to New Delhi

The Corporate Office of IWTMA has shifted from Chennai to New Delhi 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.

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