Indian Wind Power

Volume: 5 Issue: 5 December 2019 - January 2020 ₹ 10/-

Bimonthly, Chennai

WIND Answers the Climate Change Call!!

The industry comes together to Challenge Climate Changes P. 3

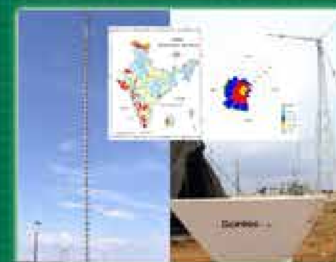
INSIDE:

IWTMA
INDIAN WIND TURBINE MANUFACTURERS ASSOCIATION

Expertise offered to Wind & Solar Energy Stakeholders

Wind Resource Assessment

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



Offshore Wind Energy

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

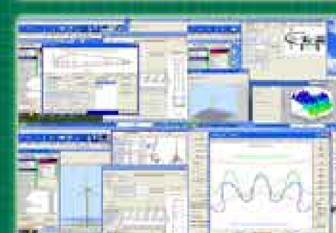
Testing (Large & Small) & Forecasting

As per Internationally accepted procedures and stipulations for

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

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

- Wind Power Forecasting Services
- Duration Test



Standards & Certification

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

Training

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

Solar Radiation Resource Assessment

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

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

नीवे NIWE

NATIONAL INSTITUTE OF WIND ENERGY

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

Velachery - Tambaram Main Road, Pallikaranai, Chennai - 600 100

Phone : +91-44-2246 3982 / 83 / 84 Fax : +91-44-2246 3980 E-mail : info.niwe@nic.in Website : http://niwe.res.in

INDIAN WIND TURBINE MANUFACTURERS ASSOCIATION

Indian Wind Power

A Bi-monthly Magazine of Indian Wind Turbine Manufacturers Association

Volume: 5 Issue: 5 December 2019 – January 2020

Contents

Page No.

Indian Wind Turbine Manufacturers Association

4th Floor, Samson Tower, 403 L, Pantheon Road, Egmore
Chennai - 600 008.
Email : secretarygeneral@indianwindpower.com
associatedirector@indianwindpower.com
Website : www.indianwindpower.com

(For Internal Circulation only)

From the Desk of the Chairman – IWTMA

Dear Readers,

Greetings from IWTMA!

The industry is happy to note the allocation of Rs. 22,000 Crores for Power and Renewable Energy announced by the Finance Minister in the Union Budget. Also, the announcement for lower Corporate Tax of 15% to new energy companies is a very bold and welcome move that provides a major boost to the clean energy sector. It has been proposed in the budget to remove the Dividend Distribution Tax (DDT) and adopt the classical system of dividend taxation under which the companies would not be required to pay DDT. The dividend shall be taxed only in the hands of the recipients at their application rate. It is unfortunate to note that there was no specific mention of Wind power as compared to Solar power in the budget, however, there is a mention of window for MSME to invest in Wind sector.

The Wind industry fraternity is in continuous engagement with Ministry of New & Renewable Energy (MNRE) on ways and means to address the slowdown of the last three years. It is proposed; that we need to look at ways of achieving the targets of the Government which will result in capacity addition of 10 GW per annum. The new approach of Multi-model Procurement will include Wind-Solar Hybrid, Round The Clock (RTC) Power and combining Renewable Energy and Thermal may be the answer instead of dependence only on Central Procurement through Reverse Bidding. The postponement of Reverse Bidding auctions, time and again, is sending a negative signal to Original Equipment Manufacturers (OEMs), Bidders, Bankers and other lending institutions.

National Institute Wind Energy (NIWE) has put on public domain the new Wind Atlas with an estimated potential of 679 GW at 120 meter hub height. Recently, a team from the Ministry and Industry explored the possibility of installation of wind turbines in Leh/Ladakh region. Certain measurements have been carried out which look positive, but transportation logistics may pose a problem and one has to study the geo-technical issues before commercial exploitation. Government is continuing its support for development of offshore both in Gujarat and in Tamil Nadu.

We wish to update our readers that the run up of Windergy India 2020 is gaining momentum and we are sure, with the support of the Ministry, Industry and International fraternity, it would be a great opportunity for discussion on various topics to achieve the Government's aspirational target and an exhibition to showcase technology and services. We request our readers support in participation as exhibitors, delegates and visitors.

'Wind is the answer' to climate change and global warming and with 80% localization and wind installations in the rural sector provides immense opportunity both for MSME industries and job opportunities to the educated youth in the rural sector.

I, on behalf of IWTMA, wish the readers a 'Happy Holi' and look forward to meeting you at the Windergy India 2020.

With regards,

Tulsi Tanti
Chairman

Wind is the answer to Climate Change Challenges

Indian Wind Turbine Manufacturers Association (IWTMA), along with PDA Trade Fairs Pvt Ltd. and participation of Global Wind Energy Council (GWEC) as an International Cooperation Partner, is organising the 4th edition of India's only comprehensive International Trade Fair and Conference for the Wind sector, Windergy India 2020 by the Wind Industry. The event will be held from 28th to 30th April 2020 at the India Expo Centre & Mart (IEML), Greater Noida, India. This flagship event is supported by Ministry of New & Renewable Energy (MNRE), Government of India.

India is one of the countries, with the most extensive production of energy from renewable sources and 23.3% (Source: CEA) of the total installed power capacity is from renewable energy, of which, around 43.7% (Source: CEA) is contributed by Wind Energy (around 37.5 GW). The country pledged, by 2030, 40% of installed power generation capacity in the country shall be based on clean sources, of which 175 GW of renewable energy capacity will be installed by 2022. This includes 100 GW from Solar, 60 GW from Wind, 10 GW from Bio-power and 5 GW from small Hydropower.

The Indian Wind Energy manufacturing capacity is 10 GW per annum and has achieved around 80% indigenization which is in line with "Make in India" initiative. The supply chain is supported by 4000 vendors of which majority are from MSME sector. Majority of wind installations happen in the rural India thereby a very positive social impact on the rural economy.

Wind Resource Assessment by National Institute of Wind Energy (NIWE) has announced a potential of onshore wind of 600+ GW at 120 meter hub height. India has a signatory to COP-21 has pledged 60 GW by 2022 and 140 GW by 2030 and basket of 450 GW of RE. It is a matter of pride that India can boast of the lowest cost of the turbine and project in the world thereby attracting Global Investment and a great opportunity to export state-of-the art turbines and components. The industry appreciates the policy initiatives of Central and State Government and regulatory intervention for an orderly all inclusive growth.

Windergy India 2020 projects to bring around 6000 key decision-makers including DISCOMs, Independent Power Producers, Governments, Corporates, International Organisations, Non-Profit Organisations, PSUs, Non-Governmental Organisations, R&D Institutions and many more besides Wind Turbine and Component Manufacturers, for three days of industry meet, interaction and deliberation on the future of wind power in India.

Attendees can gain by meeting over 200+ Indian and international wind energy technology companies who will be exhibiting cutting edge wind power production & distribution solutions and technologies. The event offers unmatched networking opportunities and 3 days of intense deliberations at the international conference.

Actual Penalty and Deviation Settlement Mechanism (DSM) Penalty in Interstate F&S Regulation for RE Generators

Abhik Kumar Das
Technical Director
del2infinity Energy Consulting
contact@del2infinity.xyz

Sandeep Suman
Assistant Manager (E&M)
Coal India Limited

1. Introduction

Forecasting and Scheduling (F&S) of solar and wind power generation is required to manage the grid network for maximum utilization of renewable energy. Hence the concept of forecasting and scheduling (F&S) of renewable energy generators and the commercial settlement was introduced in Indian context by CERC through Indian Electricity Grid Code (IEGC), 2010[1] and the Renewable Regulatory Fund mechanism[2]. Due to several implementation issues, the mechanism was never made operational. To formulate an implementable framework, CERC also issued 2nd amendment to regulation for the Deviation Settlement Mechanism (DSM) and other related matters[3]. After CERC regulation, Forum of Regulators (FOR)[4] and other state regulators issued or drafted regulation related to the forecasting and scheduling of wind and solar power generation. Unlike DSM penalty of intrastate forecasting and scheduling of wind and solar power generation, the 'actual penalty' and the 'DSM penalty' of wind and solar power generation in interstate CERC regulation are different. This article briefly focuses on the theoretical and evidence based understanding of 'Actual Penalty' and 'DSM Penalty' in case of interstate regulation.

2. Theoretical Framework

In interstate regulation, the payment is on schedule generation, unlike the intrastate in which the payment is on actual generation. Hence, to calculate the actual penalty due F&S in case of interstate regulation, we can state that,

Actual Penalty =
(Schedule Generation × PPA rate + DSM Penalty) -
Actual Generation × PPA rate (1)

Here DSM penalty is negative when payable to the pool by the generators and positive when payable by the pool to the RE generators. By simple algebraic manipulation (1) can be written as,

Actual Penalty =
DSM Penalty - (Actual Generation - Schedule generation) × PPA rate (2)

Which transforms into,

Actual Penalty (P) =
DSM Penalty (Δ) - Energy Deviation (δ) × PPA rate (p) (3)

$$\text{i.e. } P = \Delta - \delta p \qquad (4)$$

Here (4) can be viewed as the fundamental equation to calculate the actual penalty in interstate F&S regulation. Since (4) is true for each of the time-block, for all time-blocks we can state that,

$$\sum P = \sum \Delta - p \sum \delta$$

If we replace, $\sum P$ as P, $\sum \Delta$ as Δ and $\sum \delta$ as δ, (4) remains same, and the total actual penalty (monthly or weekly) can be calculated from the total DSM (monthly or weekly) and total energy deviation (monthly or weekly). Interestingly, total DSM and total energy deviation value (monthly or weekly) is readily available at ERC sites, and the actual penalty can be calculated if the PPA rate (p) is known.

Hence, (4) can be viewed as a fundamental equation to calculate the actual penalty in interstate regulation.

Since $P = \Delta - \delta p$, it is easy to state that the actual penalty due to the deviation (P) is not the DSM penalty (Δ).

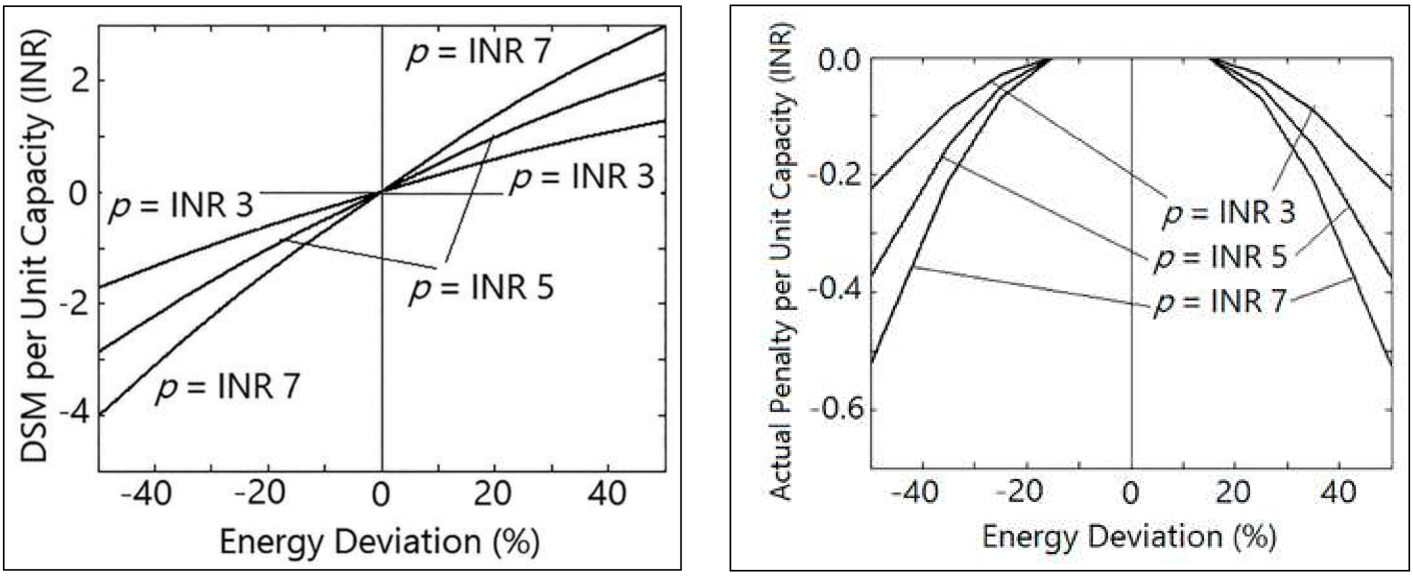
Since the actual penalty (P) is always payable, it is always negative. Hence, DSM penalty (Δ) and energy deviation (δ) are of same sign, as shown in Table I.

Table I: DSM Penalty vs Energy Deviation

DSM penalty (Δ)		Energy deviation (δ)		Comment
+	DSM Receivable	+	Actual > Schedule	Under-schedule / Over-injection
-	DSM Payable	-	Actual < Schedule	Over-schedule / Under-injection

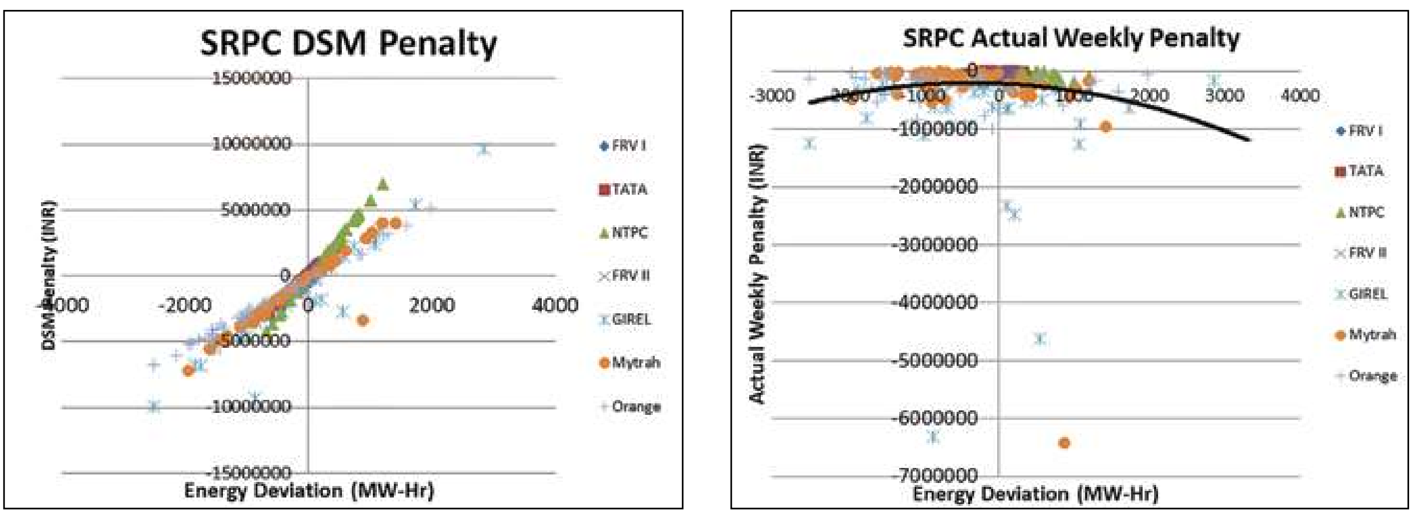
Table II: DSM for Inter-State Regulation and Mathematical Framework

	Payment on Schedule Generation	Payment on Schedule Generation
Abs Error $\widehat{\delta} = \frac{\delta}{AvC}$	For Under-Injection (Actual < Schedule) Deviation Charge payable by RE generators Δ	For Over-Injection (Actual > Schedule) Deviation Charge payable to RE generators Δ
0 – 15%	At the Fixed Rate for the shortfall energy upto for absolute error upto 15% δp	At the Fixed Rate for the excess energy upto for absolute error upto 15% δp
15% - 25%	At the Fixed Rate for the shortfall energy for absolute error upto 15% + 110% of the Fixed Rate for balance energy beyond 15% and upto 25% 0.15 Ap + [δ - 0.15A] X (1.1 p)	At the Fixed Rate for the excess energy for absolute error upto 15% + 90% of the Fixed Rate for balance energy beyond 15% and upto 25% 0.15 Ap + [δ - 0.15A] X (0.9 p)
25%-35%	At the Fixed Rate for the shortfall energy for absolute error upto 15% + 110% of the Fixed Rate for balance energy beyond 15% and upto 25% + 120% of the Fixed Rate for balance energy beyond 25% and upto 35% 0.15 Ap + 0.1 A (1.1p) + [δ - 0.25A] X (1.2 p)	At the Fixed Rate for the excess energy for absolute error upto 15% + 90% of the Fixed Rate for balance energy beyond 15% and upto 25% + 80% of the Fixed Rate for balance energy beyond 25% and upto 35% 0.15 Ap + 0.1 A (0.9p) + [δ - 0.25A] X (0.8 p)
>35%	At the Fixed Rate for the shortfall energy for absolute error upto 15% + 110% of the Fixed Rate for balance energy beyond 15% and upto 25% + l20% of the Fixed Rate for balance energy beyond 25% and upto 35% + l30% of the Fixed Rate for balance energy beyond 35% 0.15 Ap + 0.1 A (1.1p) + 0.1 A (1.2p) + [δ - 0.35A] X (1.3 p)	At the Fixed Rate for the excess energy for absolute error upto 15% + 90% of the Fixed Rate for balance energy beyond 15% and upto 25% + 80% of the Fixed Rate for balance energy beyond 25% and upto 35% + 70% of the Fixed Rate for balance energy beyond 35% 0.15 Ap + 0.1 A (0.9) + 0.1 A (0.8p) + [δ - 0.35A] X (0.7 p)



(a) (b)

Figure 1: Shows the percentage of energy deviation vs (a) DSM penalty per unit capacity and (b) Actual penalty per unit capacity as per the Interstate regulation using the equation in Table II.



(a) (b)

Figure 2(a) shows the energy deviation (MW-Hr) vs (a) Weekly DSM Penalty and 2(b) Weekly Actual Penalty for 7 different generators at SRPC. The bold black curve in 2(b) shows the average trend line.

Since different RE generators are of different capacities, to normalize the calculation, let divide (4) by the available capacity (AvC), i.e.

$$\frac{P}{AvC} = \frac{\Delta}{AvC} - p\frac{\delta}{AvC}$$

$$\Rightarrow \quad \hat{P} = \hat{\Delta} - p\hat{\delta}$$

Where $\hat{P}$ is penalty per unit capacity, $\hat{\Delta}$ is DSM per unit capacity and represents the percentage in energy deviation. Hence, as per interstate F&S regulation, the equation relating to 'DSM penalty' and 'percentage in energy deviation' can be represented as in Table II.

3. Results and Discussion

Using the equation in Table II, the percentage of energy deviation vs DSM penalty per unit capacity for different PPA rate (p) can be shown as in Figure 1(a). According to Figure 1(a), when the energy deviation is positive (negative), the DSM penalty is positive (negative). It is interesting to see that the curve representing DSM penalty vs. energy deviation is continuous, though the function seems to be an odd function (f(-x) = - f(x)), the curve is not an odd function, i.e. for same energy deviation in the positive and negative direction the DSM penalty for under-schedule and over-schedule are not same ($f(-\delta) \neq -f(\delta)$).

The Actual Penalty vs energy deviation is shown in Figure 1(b) for different values of PPA rate (p). Here it is interesting to see that the curve is symmetric about the y-axis and it is an even function ($f(-x) = f(x)$). Hence, for same energy deviation in the positive and negative direction the Actual penalty for under-schedule and over-schedule are same ($f(-\delta) = f(\delta)$). Hence, as per interstate regulation, if the forecast is over-scheduled or under-scheduled, the actual penalty remains the same for same energy deviation in positive or negative direction.

The theoretical structure of 'Actual Penalty' and 'DSM Penalty' is validated by evidence based data of 7 different RE generators of the Southern Regional Power Committee (SRPC) website[5] where DSM data and energy deviation data are openly available. As shown in Figure 2(a), the DSM penalty data vs energy deviation data has close match with the curve in Figure 1(a). Though it is expected that the actual penalty value in Figure 2(b) will closely match the nature of curve in Figure 1(b), the 'actual penalty' in Figure 2(b) is very scattered due to the high value of the penalty due to erroneous forecast. From Figure 2 (a) and (b), we can state that the tendency of over-schedule the forecast is very high, though it is evident from Figure 1(b) that the actual penalty for under-schedule and over-schedule is same for the same amount of energy deviation.

4. Conclusion

This article shows a simple method of calculation the 'actual penalty' as per DSM in the case of interstate regulation since the DSM penalty and 'Actual Penalty' are not same in case of interstate regulation unlike to intrastate. The $P = \Delta - \delta p$ rule is an easy way to compute the actual penalty value since the values are easily available at weekly or monthly bill of DSM settlement. The article shows the theoretical structure for energy deviation vs Actual Penalty curve from which we can state that the actual penalty for under-schedule and over-schedule are same for the same amount of energy deviation.

References

1. Indian Electricity Grid Code, Central Electricity Regulatory Commission, 2010 (http://cercind.gov.in/2010/ORDER/February2010/IEGC_Review_Proposal.pdf)
2. Procedure for implementation of the mechanism of Renewable Regulatory Fund, Central Electricity Regulatory Commission, 2011 (http://www.cercind.gov.in/Regulations/Detailed_Procedure_IEGC.pdf)
3. Framework on Forecasting, Scheduling and Imbalance Handling for Variable Renewable Energy Sources (Wind and Solar), Central Electricity Regulatory Commission, (http://www.cercind.gov.in/2015/regulation/SOR7.pdf)
4. Model Regulations on Forecasting, Scheduling and Deviation Settlement of Wind and Solar Generating Stations at the State level.http://www.forumofregulators.gov.in/Data/study/MR.pdf)
5. http://www.srpc.kar.nic.in/html/all_uploads.html

Snippets on Wind Power

Renewables Need to Double by 2030 to Reach Climate Goals – IRENA

The share of renewables in the global energy mix should more than double by 2030 to advance the global energy transformation, achieve sustainable development goals and a pathway to climate safety, according to the International Renewable Energy Agency (IRENA). Renewable electricity should supply 57% of the global power by the end of the decade, up from 26% today. The Agency's data shows that annual renewable energy investment needs to double from around $330 billion today to close to $750 billion to deploy renewable energy at the speed required. Much of the needed investment can be met by redirecting planned fossil fuel investment. Close to $10 trillion of non-renewables related energy investments are planned to 2030, risking stranded assets and increasing the likelihood of exceeding the world's 1.5 degree carbon budget this decade.

Source: Smart Energy International, Jan 13, 2020

Electricity Act May Be Amended To Ensure Discoms Honour Power Pacts

The government is planning to introduce a bill to amend the Electricity Act to prevent states from reneging on power pacts, particularly renewable energy contracts, and distribution companies from defaulting on bills. It wants to ensure that renewable energy tariffs are not changed after execution of contracts, and electricity regulatory commissions have more teeth to enforce power purchase agreements between projects and distribution companies (discom), a senior government official said. The proposal comes after the new governments in Andhra Pradesh and Maharashtra refused to honour power purchase agreements, leaving investors jittery.

Source: ET Bureau, January 17, 2020

Need for the Lead Auditor for Wind Turbine Type Certification, Asset Management, Carbon/ Water Footprint and Sustainable Development

Dr. Sanjiv Kawishwar, Ph.D Renewable Energy
Director, CORE (Center Of Renewable Energy), India

Introduction

The requirement of a Lead Auditor is must for wind turbine Type Certification. Such leadership qualification in renewable energy field helps to achieve higher management level and sustenance in RE sector.

The Lead Auditor Training provides:

✓ Additional Qualification with Skill Development

✓ Professional level upgradation (to management level)

✓ Enhanced understanding of standards used for compliance

✓ Consulting and training opportunities

In order to remain competitive and grow in any industry one must acquire pertinent 'Qualifications' in relevant domain on a continual basis. CORE provides such qualification in renewable energy field.

Qualification

Individual's renewable competance gets recognised when he obtains leadership qualification (e.g. Lead Auditor) for:

- Type Certification (IECRE OD-501 / IS : IEC 61400-22)
- RE Efficiency and Energy Management (IEC 13273 & ISO 50001)
- Project Certification (IECRE OD-502)
- Total Quality Management
- Six Sigma (ISO 13053)
- Asset Integrity Management (ISO 55001)
- Carbon Footprint (ISO 14067)
- Water Footprint (ISO 14046)
- Sustainable Development Goals

Type Certification (IECRE OD-501/IS: IEC 61400-22)

Type a certificate is issued by a certifying body, when it has been demonstrated that a product type/wind turbine type complies with the applicable regulations/standards. A type certificate is issued to signify the worthiness of a wind turbine manufacturing design or "type". The purpose of type certification is -

➢ to confirm that wind turbine type is designed, documented & manufactured in conformity with design assumptions, specific standard & technical requirements.

➢ to demonstrate that it is possible to install, operate and maintain turbines in accordance with design documentation.

Type certification consists of the modules:

- Design basis evaluation (mandatory)
- Design evaluation (mandatory)
- Type testing (mandatory)
- Manufacturing evaluation (mandatory)
- Final evaluation (mandatory)
- Foundation design evaluation (optional)
- Foundation manufacturing evaluation (optional)
- Type characteristic measurements (optional)

A Type certificate according to IECRE OD-501/IS:IEC 61400-22 is mandatory for commercial production as well as grid commissioning of wind turbine in India.

RE Efficiency and Energy Management (IEC 13273 & ISO 50001)

Energy management system is a set of interrelated or interacting elements to establish an energy policy and energy objectives, and processes and procedures to achieve those objectives. Implementation of the energy management system with integration of RE Efficiency (IEC 13273) system yields the optimum energy.

Project Certification (IECRE OD-502)

Project certification

➢ Constitute a third-party conformity assessment of a complete wind farm.

➢ Applies to both onshore and offshore installation.

- specifies procedures for project certification with respect to specific standards and other technical requirements, relating to safety, reliability, performance, testing and interaction with electrical power networks.
- provide guidance for documentation.
- not limited to wind turbines of any particular size or type.

Project certification process results in one of the following:

- Project design certificate
- Project certificate
- Site-suitability evaluation conformity certificate

Total Quality Management (TQM)

TQM is a management approach that is centred on quality and based on the participation of each member of the organization.

TQM is a management philosophy that seeks to integrate all organizational functions (marketing, finance, design, engineering, and production, customer service, etc.) to focus on meeting customer needs and organizational objectives.

Objective of TQM is "Do the right things, right the first time, every time."

Joseph Juran & William E. Deming were the founders of TQM.

Quality Management Principles

Eight quality management principles are:

1. Customer Focus
2. Leadership
3. Involvement of people
4. Process Approach
5. System Approach
6. Continual Improvement
7. Factual Approach to Decision making
8. Mutually Beneficial Supplier Relationship

Asset Integrity Management (ISO 55001)

Organisations must be now geared to implement Asset Management Systems (ISO 55001) with integration of Energy management, Carbon Footprint, Water Footprint and focus on achieving Sustainable Development Goals set by UN.

Conclusion

The RE Sector relies fundamentally on optimized supply chains for high-value components. Today, awareness and interest in TQM best practices is higher than ever, with RE companies actively competing for such prizes as the Deming Award. It is thus necessary to have skill and leadership to drive change in this environment.

Center of Renewable Energy (CORE) has been established to meet an unmet gap in the RE industry of providing an expert 'Advisory and Academic Qualification/ Training' in the wind and solar domain.

Snippets on Wind Power

MNRE Issues Draft Policy for Round-the-Clock Supply of Bundled Renewable Power

The Ministry of New and Renewable Energy (MNRE) has proposed a draft policy for the supply of Round-The-Clock (RTC) power to discoms which would be a mix of renewable energy and electricity generated in coal-based plants. The idea is to address the biggest issue with large scale uptake of clean energy – intermittency. Solar and wind energy are not available throughout the day severely limiting their use in modern grids. "The main objective of the scheme is to provide RTC power to the DISCOMs through bundling of RE power with thermal power and to scale up renewable capacity additions. It will also facilitate fulfilment of renewable purchase obligation (RPO) requirement of the obligated entities," the ministry said inviting comments from stakeholders on the key provisions of the new scheme.

Source: ET Energy World, January 02, 2020

Ladakh Has Wind Power Potential of 1 Lakh MW: NIWE DG Balaraman

Ladakh has a wind power potential of 1 lakh MW and preliminary studies have indicated the region holds tremendous promise for setting up commercial scale wind energy projects, according to Dr. K Balaraman, Director General of Chennai-based National Institute of Wind Energy (NIWE). It has good wind resource due to its valley terrain and temporal variation with an estimated potential of 5,311 MW at a hub height of 50 meter and it goes up to 100,000 MW at a height of 120 meter. After the identification of potential locations NIWE and SECI will together plan the grid evacuation infrastructure development including logistics details in coordination with Border Roads Organization.

Source: Economictimes.indiatimes.com, Dec 17, 2019

BIDS AWARDED AND COMMISSIONED FOR WIND POWER

Bids Commissioned till 31st December 2019

Solar Energy Corporation of India (SECI) Bids for Wind Power

S. No.	Bids Completed	Capacity	Scod	Bidder	Tariff	State	Bid Capacity	Project Commissioned			
								Capacity Breakup	2018-19	2019-20	Grand Total
		MW			Rs./kWh		MW	MW	MW	MW	MW
1	SECI - I (24th February 2017)	1050	5-03-19	Mytrah	3.46	Tamil Nadu	250	250	624.8	375.2	1000
				Inox	3.46	Gujarat	250	200			
				Ostro	3.46	Gujarat	250	250			
				Green Infra/Sembcorp	3.46	Tamil Nadu	250	250			
				Adani	3.46	Gujarat	50	50			
2	SECI-II (4th October 2017)	1000	3-05-19	Renew	2.64	Gujarat	250	180	0	605	605
				Orange	2.64	Tamil Nadu	200	200			
				Inox	2.65	Gujarat	250				
				Green Infra/Sembcorp	2.65	Tamil Nadu	250	175			
				Adani	2.65	Gujarat	50	50			
3	SECI - III (13th February 2018)	2000	24-11-19	Renew	2.44	Gujarat	400		0	416.2	416.2
				Green Infra/Sembcorp	2.44	Gujarat	300	300			
				Inox	2.44	Gujarat	200				
				Torrent	2.44	Gujarat	499.8				
				Adani	2.45	Tamil Nadu	250	66			
				Alfanar	2.45	Gujarat	300				
				Betam/Engie	2.45	Tamil Nadu	50.2	50.2			
4	SECI - IV (5th April 2018)	2000	28-02-20	Srijan Energy/Continnum	2.51	Gujarat	250		0	0	0
				Sprng Energy/Actis	2.51	Tamil Nadu	300				
				BLP/ENEL	2.51	Gujarat	285				
				Betam/Engie	2.51	Tamil Nadu	200				
				Inox	2.51	Gujarat	100				
				Adani	2.51	Gujarat	300				
				Mytrah	2.52	Tamil Nadu	300				
				Renew	2.52	Gujarat	265				
5	SECI - V (25th September 2018)	1200	22-09-20	Torrent Power	2.76	Gujarat	115		0	0	0
				Adani	2.76	Gujarat	300				
				Alfanar	2.77	Gujarat	300				
				Sitac	2.77	Gujarat	300				
				Ecoren	2.77	Karnataka	175				
				Renew	2.77	Gujarat	10				

-continued-

Solar Energy Corporation of India (SECI) Bids for Wind Power

S. No.	Bids Completed	Capacity	Scod	Bidder	Tariff	State	Bid Capacity	Project Commissioned			
								Capacity Breakup	2018-19	2019-20	Grand Total
		MW			Rs./kWh		MW	MW	MW	MW	MW
6	SECI-VI (15th February 2019)	1200	Feb-21	Adani	2.82	N.a	250		0	0	0
				Renew	2.82	Tamil Nadu	300				
				Continuum	2.82	N.a	150				
				Powerica	2.82	N.a	50.6				
				Ecoren	2.83	Karnataka	125				
				Softbank	2.83	Maharashtra	324.4				
7	SECI-VII (14th May 2019)	480	May-21	Engie	2.79	N.A	200		0	0	0
				Renew	2.81	N.A	50				
				Sprng	2.82	MP	100				
				Adani	2.83	Gujarat	130				
8	SECI -VIII (30th August 2019)	440.64	Aug-21	CLP	2.83	Gujarat	250.8		0	0	0
				Avikiran Energy/ENEL	2.84	Gujarat	189.84				
	TOTAL	9370.64							624.8	1396.4	2021.2
	NTPC & STATES BIDS (WIND)										
9	NTPC (21st August 2018)	1200	May-20	Sprng Vayu	2.77	MP	200		0	0	0
				Mytrah	2.79	Tamil Nadu	300				
				Srijan Energy/Continnum	2.8	Gujarat	50				
				Renew	2.81	Kar/Gujarat	300				
				Hero	2.82	Kar/Gujarat	300				
				Sitac/EDF	2.83	N.A	50				
10	Tamil Nadu (28th August 2017)	450	May-19	Regen Powertech	3.42	Tamil Nadu	200	50	50	0	50
				Leap Energgy	3.43		250	0			
				NLC	3.45		0	0			
11	Gujarat (GUVNL) (21st December 2017)	500	Oct-19	Sprng Energy	2.43	Gujarat	197.5	197.5	104.9	395.1	500
				K.P. Energy	2.43		30	30			
				Verdant/Sitac	2.44		100	100			
				Betam Wind/Engie	2.44		29.9	29.9			
				Powerica	2.44		50	50			
				Renew	2.45		35.7	35.7			
				Oil India	2.43		18.9	18.9			
				Sjvnl	2.43		38	38			

-continued-

NTPC and State Bids (Continued)

S. No.	Bids Completed	Capacity	Scod	Bidder	Tariff	State	Bid Capacity	Project Commissioned			
								Capacity Breakup	2018-19	2019-20	Grand Total
		MW			Rs./kWh		MW	MW	MW	MW	MW
12	MSEDCL (6th March 2018)	500	Jan-20	Adani	2.85	Gujarat	75		0	202	202
				KCT/Renew	2.85	Maharashtra	75	50			
				Inox	2.86	Gujarat	50				
				Mytrah	2.86	Maharashtra	100				
				Hero	2.86	Maharashtra	75.6				
				Torrent	2.87	Maharashtra	124.4	124.4			
13	MSEDCL (1st June 2018)	87	Mar-19	Sarla Performance Fibers Ltd	2.51	Maharashtra	6		0	0	0
				Inox	2.52		6				
				Essel Mining & Industries	2.52		75				
14	GUVNL TRANCHE - II (13th May 2019)	745	May-21	Aanisha Power	2.8	Gujarat	40		0	0	0
				Powerica	2.81		50.6				
				Vena Energy	2.81		100				
				Sarjan Realities	2.87		100.8				
				Viridi	2.95		100				
				Inox	2.95		40				
				Renew	2.95		200				
				Adani	2.95		113.6				
TOTAL		3482							154.9	597.1	752
GRAND TOTAL		12852.6							779.7	1993.5	2773.2
SUMMARY											
Total Wind Bids (SECI,NTPC,State)			12853	Bids in Gujarat	7015.44						
Total Wind Solar Hybrid Bids (SECI)			1560	Bids in Tamil Nadu	3550.2						
Total			14413	Bids in other states (Mah,Kar,MP)	2201.4						

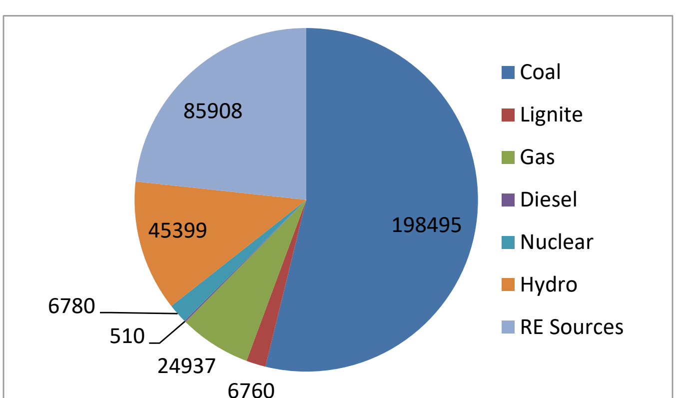
Note:-The figures may vary as it is collected verbally from several sources.

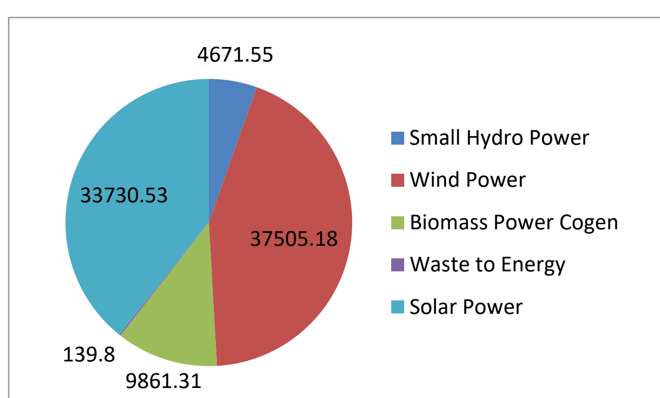
Compiled by Rishabh Dhyani, Assistant Manager, Regulatory Affairs, Policy & Liaison, IWTMA, New Delhi

India - Electricity At a Glance: December 2019

India - Electricity Installations at a Glance: December 2019 (All Figures in MW)	
Source	**Dec. 2019**
Coal	198495
Lignite	6760
Gas	24937
Diesel	510
Nuclear	6780
Hydro	45399
RE Sources	85908
Total	**368789**

Renewable Energy in India (MW)	
RE Category	**Dec. 2019**
Small Hydro Power	4671.55
Wind Power	37505.18
Biomass Power Cogen	9861.31
Waste to Energy	139.8
Solar Power	33730.53
Total RE	**85908.37**





Regulatory News December 2019 - January 2020

MNRE-Draft Scheme for RTC Power from RE Power Projects Complemented with Power from Thermal Power Projects

1. This scheme has opened up the new window for selling power to bulk consumers through open access.
2. The composite price of RE source and Thermal source will be discovered through competitive bidding process by SECI, NTPC or any other intermediary procurer.
3. The generator has to supply RE power complemented with Thermal power in RTC manner keeping at least 80% availability on annual basis ***(out of total 80%, 51% from RE and 49% from Thermal).***
4. Storage is also allowed.
5. RE component under the scheme is eligible for RPO compliance.
6. PPA term will be 25 years.
7. SECI, NTPC etc. can charge a trading margin.

Clarification Required

How a generator will bundle the RE and Thermal power together and quote a price. For that the generator should have both projects at one site or different sites. Clarity is required here.

RE Outstanding Dues

Central Government is trying to resolve the outstanding dues of renewable energy developers or beneficiaries on fast track basis with the help of Central Electricity Authority (CEA).

Central Electricity Regulatory Commission

The national electricity regulator Central Electricity Regulatory Commission has refused to approve the trading margin of 7 paisa/unit to the SECI. Beneficiaries like Punjab and Bihar have been requesting powerregulators to reduce the trading margin for renewable aggregator to 2paisa/unit.

SECI Tranche IX-1200 MW

The bid submission is postponed due to very less participation.

SECI Wind Solar Hybrid Tranche III

Wind Solar Hybrid Tranche III has been announced for 1200 MW and the upper cap is 2.88/kWh.

Central Update

1. GST

IWTMA has filed a petition at Delhi High Court for downward revision of 70:30 Ratio. Post order dated 29th May 2019 on the Petition, CBIC invited IWTMA for first round of consultation. Outcome of this meeting resulted into a request from CBIC to submit contract documents to verify Goods & Services Ratio to be placed before fitment Committee. The recommendation of the Fitment Committee would be placed before the next GST Council meeting.

2. Open Access (OA)

IWTMA is engaged with MNRE and MOP on Open Access both for captive as well as bilateral sale (third party entity). We are informed that MOP is seriously considering this channel for opening up new business. IWTMA had many meetings with MNRE and IPPs. MNRE has come up with Draft Scheme for RTC power which will open a new window for Open Access Transactions

3. Gujarat Land Issue

Gujarat after talking to MNRE decided that SECI I, II, III & IV bid winners can get Government land as per identified by bid winners (pre-identified locations). SECI V and thereafter government land can be allotted only in proposed Renewable Energy Park.

State Updates

Rajasthan Wind & Hybrid Policy 2019 - Highlights

1. REC projects have been removed from the new policy.
2. Target - Installation of 2000 MW Wind project by 2024-25 with additional 2000 MW for captive consumption through intra/interstate transactions.
3. Introduction of Repowering of Wind power projects which have completed 10 years and above.
4. Allotment of Government land and Private land for Wind & Wind Solar Hybrid Projects.
5. Formation of State Level Screening Committee (SLSC) for clearance of Wind & Wind-Solar Hybrid projects.
6. Promoting Manufacturing of Wind Energy Equipments.
   a. Benefits of MSME policy,
   b. Land allotment at 50% concessional rate,
   c. Exemption of 100% stamp duty,
   d. Full exemption of electricity duty for 10 years.
7. Installation of 3500 MW of Wind-Solar Hybrid Projects by 2024-25.
8. Captive use and sale to third party within and outside state through Open Access is allowed for Wind-Solar Hybrid Projects.

Compiled by Rishabh Dhyani, Assistant Manager, Regulatory Affairs, Policy & Liaison
IWTMA, New Delhi


Geared for
a Better Future

Direct Drive Wind Turbines Main Bearings CMS Trade-Off: Methodology Proposal and Case Study

Haral Jonas Serafini, Mechanical Engineer
Department of Development and Technological Innovation, WEG Equipamentos Elétricos S.A., Brazil
harals@weg.net

Introduction

Direct Drive (DD) wind turbine main bearings have just a few parts, providing higher reliability, but replacement may be very expensive. Wind turbines maintenance strategies include the use of Condition Monitoring Systems (CMS) to prevent unexpected downtime. This paper proposes a methodology to define whether to install a CMS in such systems. It provides an innovative suggestion that primary failure in further systems that would lead to main bearings secondary failures should also be part of CMS evaluation. A case with WEG AGW 2.2 wind turbine is partially described. With given assumptions, the results indicate that a CMS that could detect primary failures may have advantages over other CMS if the detection could avoid the bearing failure. The methodology proposed in this paper may help operators to decide when to install CMS and what features should be required.

1. Purpose of the Work

Wind turbines O&M (Operation & Maintenance) strategies for execution and optimization depend highly on reliable data from PdM (Predictive Maintenance) programs. Main components deterioration data acquisition and effective processing is mandatory to identify potential root cause of failures or failure in early stages.

Direct Drive (DD) wind turbines main bearings systems provide a very interesting case for PdM programs. In one hand, they reduced number of components and provide good reliability, especially when good design, manufacturing and assembling techniques are followed. In another hand, once generator generally integrates the main bearings in it, in some cases it is necessary to disassemble the entire heavy, big diameter generator in case main bearings are damaged, which demands a huge logistic field operation at the site including a massive crane.

This paper suggests that the selection of a main bearing CMS demands a careful trade-off analysis by wind turbine operator, in order to mitigate risks of the related uncertainties and to optimize CMS costs. LCC (Life-Cycle Cost) analysis is proposed as method for such trade-off, as well as suggestions for assumptions and parameters to be chosen.

2. Approach

2.1. Direct Drive Main Bearings

Gearless wind turbines main bearings could present several design topologies[2] as per examples of Figure 1.

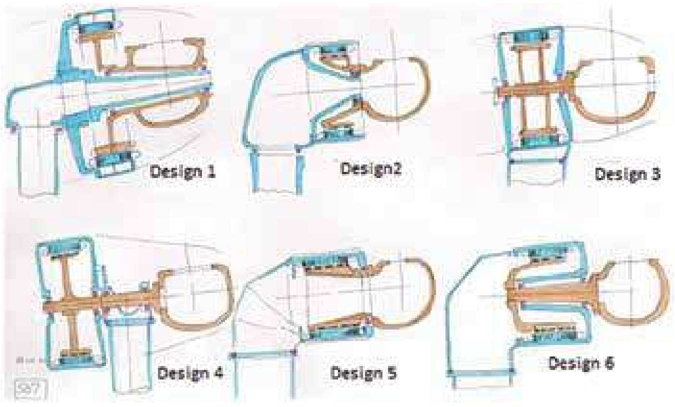


Figure 1: DD Wind Turbine Arrangements for Inner Generator Rotor (Adapted from[2])

One particular feature of eventually all DD main bearings arrangements is the intervention cost needed for bearing replacement. As per Figure 1, for example, it is always necessary to remove at least one big component, that it could the blade rotor, the generator, both or the entire tower top. In all cases, a high weight capacity, more height crane is necessary. Such cranes are very expensive and could reach almost the order of millions of Brazilian Reals, including mobilization, demobilization and operation hours. Industry experience also shows that anticipating the date of a field operation does not change too much the cost of the crane.

Another particular feature is that they are generally pre-loaded bearings. Pre-loads are applied in bearings to prevent looseness under external applied loads conditions that may lead to shocks that could generate small defects in the bearing surfaces favoring pitch or cracking along the time.

2.2. Reliability of DD Main Bearings

Reliability of main bearings can be assumed to follow Weibull distribution[3]. Equation 1 shows the 3-parameters Weibull cumulative distribution function.

$$F(t,\beta,\eta,\gamma) = 1 - e^{\left(-\left(\frac{t-\gamma}{\eta}\right)^{\beta}\right)} \quad \text{Equation 1}$$

Where:

$F(t, \beta, \eta, \gamma)$ = cumulative distribution function

β = shape parameter (or slope)

η = scale parameter (or characteristic life)

γ = location parameter

For main bearings, shape parameter β could be assumed constant. Proper values can be found with bearing suppliers or in literature.

Scale parameter η can be estimated given a calculated rating life. In this case, the Eq. (1) is solved for η giving certain t that equals a calculated "Ln", being "Ln" a number of hours with accumulated probability of failure n. For example, given main bearing calculated service life of L10 = 17.000hrs, Equation 1 is solved for η, with a proper β and γ, given t = 17.000hrs and given f (17.000hrs) = 10%. Location parameter g is in hours and could be assumed 0.05*L10, being L10 the main bearing calculated bearing rating life for 10% of bearings population.

For the purpose of this paper, it is convenient to understand all possible causes that could lead to a certain failure. The technique used here for this purpose is the Fault Tree Analysis (FTA). A typical wind turbine main bearing FTA could be found in[4].

CMS performance fundamentals can be found in literature. Detectability and efficiency are used to model the performance of an imperfectly performing CMS[5]. Detectability is the capability of a system to identify a certain failure mode that has happen. Efficiency is how long the CMS indicates the failure mode before this failure mode leads to complete loss of component function. In this paper, efficiency is assumed with an arbitrary time allowing the corrective maintenance be planned without incurring in big penalties resulting from unexpected failure. Detectability is assumed as the capacity of a CMS to identify a failure in such arbitrary time.

For DD wind turbines, these fundamentals are particularly interesting because, in case main bearing change be necessary, a costly crane intervention is demanded (as discussed before in this paper). Even with a high performance CMS, with high detectability in very early stages of failure, such failure will still evolve along the time even though being monitored by maintenance operator. Therefore, even the best performance CMS will not be sufficient to avoid such intervention cost in case a bearing damage happens. Costs avoided by the CMS will be limited to the eventual penalty costs and/or the wind turbine lost power production. In this paper, it will be assumed that each bearing identified with a failure will demand a crane for immediate replacement. However, this may not be the case once the crane can be contracted to disassemble more than one component. Finally, it is also expected that, after a bearing damage is identified, the bearing could run several months before replacement is necessary. Both these possibilities are not explored in this paper.

It is convenient to include in the analysis an innovative approach to evaluate CMS techniques suitable to identify not just a bearing failure, but also operational conditions that hypothetically could lead to it. For this reason, bearing failures were categorized as second order failures, while such operational conditions that lead to them will be considered as primary failure from now on. Three critical operational parameters are considered primary failures of upmost importance: bad lubrication condition, loss of pre-loading and undetected non-conformities in bearing manufacturing/design. Fatigue bearing failures are considered primary failures at all once bearings service life calculation includes phenomena associated to all operational parameters.

Bad lubrication could be caused by grease contamination due to external entrance of dirt, water or other substances; contamination due to particles from occasional wearing that are not cleaned out during re-greasing; lack of grease; and others. A bad lubricated bearing will present insufficient oil thickness that will lead to frequent wearing, causing or increasing defects on the rolling elements. Lubrication failure probability depends on the wind turbine design and maintenance practices. For example, manual lubrication systems are expected to have higher probability of failure than monitored automatic lubrication systems. Number and design of seals affects the enclosure of the region with grease and therefore affects lubricant integrity. Frequency of old grease laboratory analysis also can help to identify lubrication probability.

Loss of pre-loading could be caused by relaxation of elements that keep the bearing pre-loaded, like bolted joints or plastic deformation of bearing tracks. Pre-loading relaxation probability depends on the wind turbine manufacturing control in the bearings preload at the assembling shop, bolted joints structural margins and number of torque/tension inspections during maintenance operations.

Undetected non-conformities in main bearing manufacturing or design could include raw material chemical composition problem, wrong chosen or applied thermal treatment, out of tolerances dimensions, incorrect finishing, sharp corners, incorrect estimative of operational temperature, error in the boundary conditions of the analysis, incorrect estimative of external loading. Manufacturing and design failures are expected

Presenting the SG 2.1-122 onshore turbi the best capacity factor in low winds

Our latest offering, the SG 2.1–122 onshore wind turbine has been developed by combining proven technology with vast experience, to ensure reduced LCoE, irrespective of the geographical and environmental conditions. It has the largest rotor in its segment, which boosts production capacity. We reaffirm our commitment to empowering you with the world's most advanced wind energy technology, for we share your vision of powering a progressive future.

www.siemensgamesa.com
Phone: +91 44 39242424

ne delivering

SIEMENS Gamesa
RENEWABLE ENERGY

to be more frequent according to the experience of the bearing supplier and its quality control. Main bearing, in this context, includes not just the rings, rollers and cage, but also mating components, like shaft, housing, etc.

For the purposes of this paper, no other primary failures were considered.

It is also necessary to estimate probability for each one of the primary failure modes happens. For lubrication system and manufacturing/design problems, the "bathtube shape" curve (for more details about it, see[6]) is suggested.

A primary failure not necessarily leads to a bearing failure. A probability of occurrence of second failure in the case of occurrence of a primary one can also be defined.

2.3. LCC Method

Life-Cycle Cost Analysis (LCCA) is a technique suitable for the evaluation whether an investment should be done with given possibility to avoid further expenses. Some literatures have reported LCCA[5,1] as proper analysis to support the decision of whether to choose a CMS to monitor wind turbines. LCCA shall include modeling of an imperfectly performance CMS[5].

LCCA of wind turbines should assume at least the following groups of costs *Cm:*

$$Cm_i = Cin_i + CSp_i + CCm_i + CPm_i + CPe_i$$

Equation 2

Cm = Maximum cost for a failure *i* in a given period; *CIn* = Investment cost of condition monitoring system; *CSp* = Spare Parts cost of new asset; *CCm* = Corrective maintenance cost; *CPm* = Predictive maintenance cost; *CPe* = Penalty costs due to downtime.

The exact cost in each period depends on the probability of occurrence of each event:

$$C_j = p_{i,j} * Cm_{i,j}$$

Equation 3

p_{ij} = Probability of occurrence of a given cost event due to a failure *i* in a period *j;* depends on the FTA and CMS detectability.

All values of cost *Cj* are levelized in the time by applying present net value:

$$LCC = \sum_{j=0}^{20} \frac{C_j}{(1+WACC)^j}$$

Equation 4

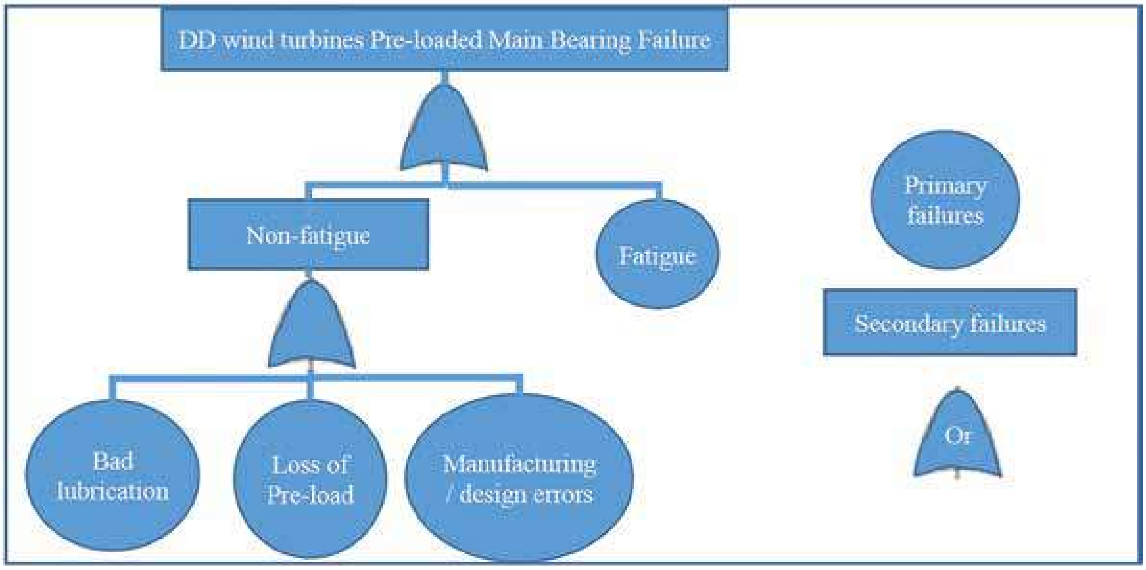
WACC = Weighted Average Cost of Capital

Several scenarios could be run after these definitions and a comparison between them could be made. One simple scenario is not to have a CMS in the main bearings. Additional scenarios could be added changing any assumption, but particularly interesting is to compare more than one CMS performances, give the extensive possibilities of CMS options[4,6,1].

2.4. Case Study

A hypothetical case study of WEG AGW 2.2 wind turbine is presented. Some of the data is shown, but some proprietary information is not disclosed and appears "confidential".

AGW 2.2 main bearings have a design topology that demands removal of rotor to disassembling the main bearings.



Graph 1: FTA for DD Wind Turbines Pre-Loaded Main Bearings

Table 1: DD Wind Turbine CMS Scenarios for Trade-Off

Scenario	CMS	Primary Failure Detectability	Secondary Failure Detectability
Scenario 1	Most expensive CMS	Performance to capture 100% of lubrication failures in time enough for solving lubrication issue before a bearing failure happens; performance to detect 0% of pre-loading failures in time enough for making a pre-loading adjustment	Performance to detect 100% of bearing failures in time enough to avoid unexpected stop
Scenario 2	Cheapest CMS	Performance to capture 20% of lubrication failures in time enough for solving lubrication issue before a bearing failure happens; performance to detect 0% of pre-loading failures in time enough for making a pre-loading adjustment	Performance to detect 100% of bearing failures in time enough to avoid unexpected stop
Scenario 3	No CMS	No detectability. If bearing fails, it will cause unexpected stop.	

The model includes main bearing reliability as Weibull cumulative distribution function as per Equation (1). Shape parameter (slope) and scale parameter (rating life) were obtained from supplier. Location parameter was as defined previously in this paper. Probability of failure in each year was then calculated using the difference of cumulative probability of year j minus the cumulative probability of year (j -1).

The model considers a specific AGW 2.2 pre-loaded main bearing FTA as per Graph 1.

Three scenarios were created as per Table 1.

For all scenarios, the following assumptions apply.

- A primary failure as per Graph 1 could happen with probability as per Table 2. Primary failure could lead to a secondary failure as per Graph 1 with an assumed probability of 100%.

Table 2: Probability of a Primary Failure along Wind Turbine Main Bearings Lifetime

Particulars	Year 1 and 2	Year 3 to 18	Year 19 and 20
Bad Lubrication condition	2.0% in year 1 1.5% in year 2	1.0%	1.5% in year 19 2.0% in year 20
Loss of pre-loading	Twice the Weibull cumulative distribution of fatigue of the bearings.		
Bearing manufacturing / design problems	Confidential	Confidential Confidential	
Fatigue	According Weibull cumulative distribution (see item 2.2)		

- Corrective costs associated according to Table 3.

Table 3: Typical Corrective Maintenance Costs Associated with a Main Bearing Failure (Amount in Brazilian Real (BRL-R$))

Cost of new set of bearings	Confidential
Cost to transport the failed generator to factory	R$ 67,000.00
Cost to disassemble/ assemble the bearings in the factory	R$ 14,489.34
Cost to mobilize / demobilize a suitable crane	R$ 750,000.00
Cost to transport new generator	R$ 67,000.00
Cost to replace generator	R$ 180,000.00
Cost to regrease after alarm	R$ 1,000.00
Cost of penalty for unexpected stop (8 weeks stop)	Confidential. Around 5 times the 1 week stop cost
Cost of penalty for planned maintenance (1 week stop)	Confidential

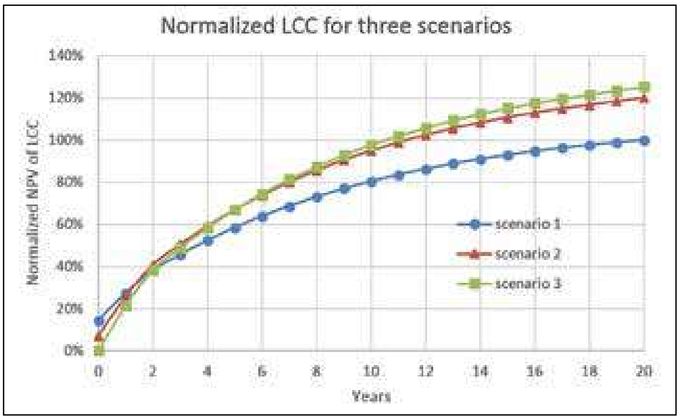
This model was run for every year from zero to the wind turbine life-time, it means, 20 years. In each year, the associated LCC was added up to the sum. WACC was assumed 13%.

3. Results

Graph 2 shows the Life-Cycle Cost (LCC) along the wind turbine lifetime, 20 years. It is normalized to preserve confidentiality of data. All three scenarios were included.

In 20 years, it is expected that a most expensive but with detectability of bad lubrication CMS leads to the lowest LCC. Not installing a CMS resulted in most expensive option, with around 125% normalized LCC.

Difference between scenario 1, with 100% normalized LCC, and scenario 2, with 120% normalized LCC, is very big. This is about three times the initial cost of the CMS considered in scenario 2. This is coherent with the fact that having a CMS that is not able to detect lubrication, pre-loading or manufacturing issues may not avoid one of the most expensive costs of maintenance, which is to have a crane to disassemble the entire generator for bearing replacement.



Graph 2: Normalized LCC for Three Scenarios (see Table 1) of AGW 2.2 Main Bearings Case

It is interesting to remark that the scenario 2, with low cost CMS, may lead to the understanding that it would not seem to be worthy: with 120% normalized LCC, it would almost the same LCC as having no CMS, 125% normalized LCC. However, it should be noted that this paper assumes contracting of the crane and replacement of the bearing immediately after CMS signalizing a fault. This is very conservative. The most realistic situation is that after the CMS indicates a failure in the bearings, the condition will then be followed-up and a proper maintenance strategy will then be applied to contract the crane in the best cost-benefit moment. This strategy may lead to several months (or even years with such low speed bearings) between the detection of the failure and the bearing replacement.

4. Conclusions

DD main bearings wind turbines are quite different of other wind turbine systems because their replacement requires a crane. In such cases, there is real value in installing a CMS for main bearings that would be able to prevent a main bearing failure by monitoring particular operational parameters.

The fact that results of the trade-off are relatively different suggests that use of the technique presented in this paper might have the potential to add value to the maintenance strategic decision, especially to decide whether to install a CMS for DD main bearings; and how to specify a CMS.

References

1. Conorado, D., Fischer, C. (2015) Condition Monitoring of Wind Turbines: State of the art, user experience and recommendations. Project Report Fraunhofer Condition Monitoring of Wind Turbines: State of the art, user experience and recommendations. Project Report Fraunhofer IWES, January 2015, January 2015.

2. Klinger, Friedrich - Müller, Lukas (2012). State of the art and new technologies of direct drive wind turbines. Congressional Research Service, Retrieved May 7th, 2017 from the World Wide Web: http://www.wind-energy-research.de/Publikationen/public/filecache/pub017-2012-state-of-the-art-paper.pdf

3. Ben Ali, J., Chebel-Morello, B., Saidi L., Malinowski, S., Fnaiech, F. 2014. Accurate bearing remaining useful life prediction based on Weibull distribution and artificial neural network. Mechanical Systems and Signal Processing 56-57 (2015) 150-172.

4. Marquez, F. P. G., Tobias, A. M., Pérez, J. M. P., Papaelias, M. (2012). Condition monitoring of wind turbines: Techniques and methods. Renewable Energy 46 (2012) 169-178.

5. Van Horenbeek, A. 2013. Information-based maintenance optimization with focus on predictive maintenance. Doctor in Engineering dissertation. *KU Leuven – Faculty of Engineering Science.*

6. Tchakoua, P., Wamkeue, R., Ouhrouche, M., Slaoui-Hasnoaoui, Fouad, Tameghe, T. A., Ekemb, G. (2014). Wind Turbine Condition Monitoring: State-of-the-Art Review, New Trends, and Future Challenges. *Energies* 214, 7(4), 2595-2630.

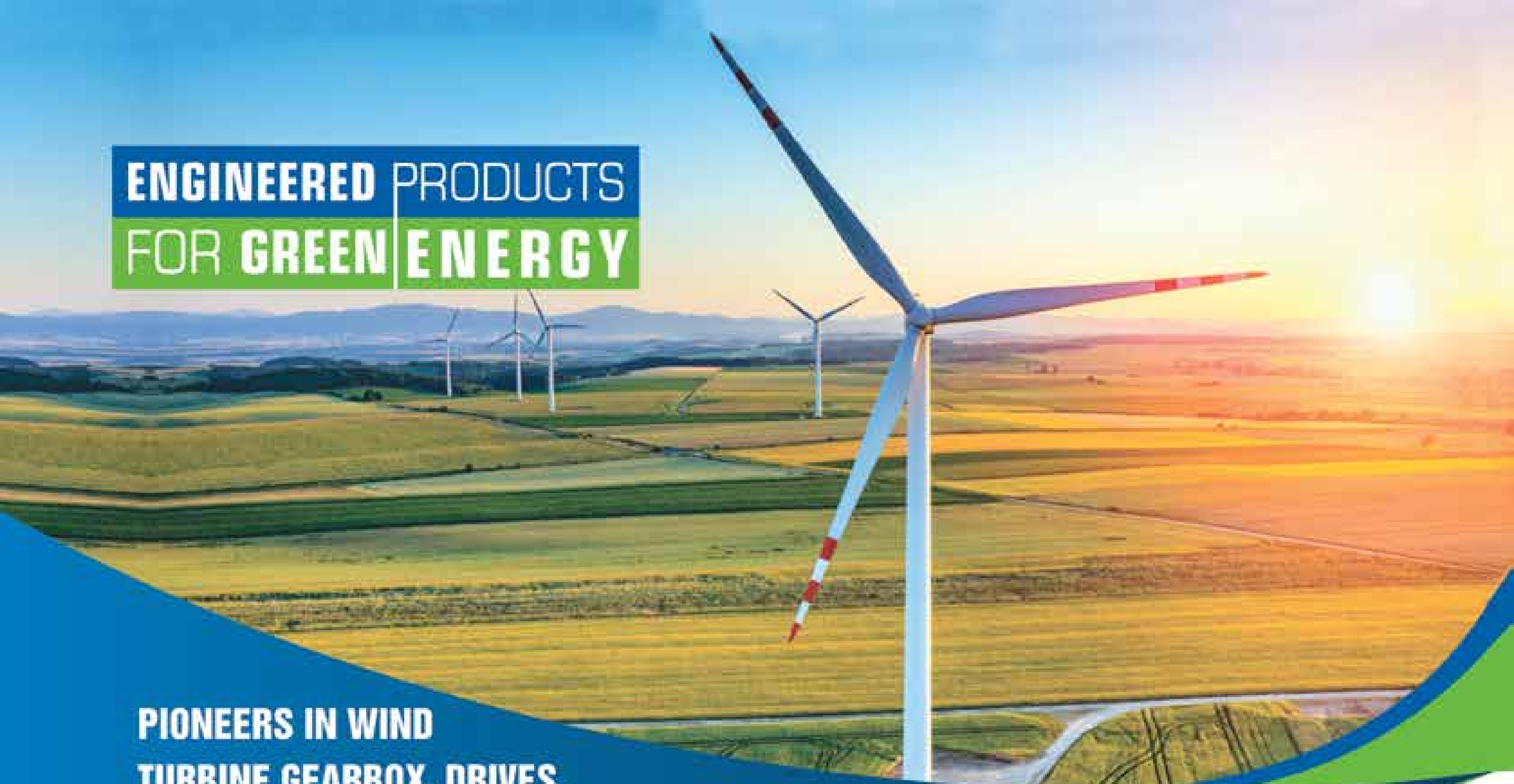
Snippets on Wind Power

NTPC Signs Largest-Ever Single Foreign Currency Loan for $750 Million

National Thermal Power Corporation announced on 3rd February 2020 that it has signed a syndicated loan in Japanese Yen equivalent to $750 million. This is the largest-ever syndicated JPY loan raised by any Asian corporate from offshore Samurai loan market. It is also the highest-ever single foreign currency loan raised by NTPC. The loan has been raised under the automatic route of Reserve Bank of India's External Commercial Borrowing regulations and has a door-to-door maturity of 11 years under two tranches. The loan proceeds will be utilized for funding capex for installation of Flue Gas Desulphurization (FGD) system, hydro projects and other projects using ultra supercritical technology with low carbon emission.

Source: ET Energy World, February 03, 2020

ENGINEERED PRODUCTS FOR GREEN ENERGY



PIONEERS IN WIND TURBINE GEARBOX, DRIVES, CASTED / FORGED / MECHANICAL COMPONENTS AND IT'S RELATED SERVICES

DHHI Group: Leading Wind Turbine components supplier worldwide, more than 35,000 wind turbines are operated Globally with DHHI products and DHHI has supplied various components for different wind turbine makes ranging from 225KW to 6MW (Onshore & Offshore).

DHHI India: Since 2010, DHHI India started its operation as 100% subsidiary in New Delhi and has supplied various components for different wind turbine makes ranging from 225KW to 3MW, more than 2500 x Wind Turbine components from DHHI are operating in various sites at India for more than 7 years without major issues.

Products supplied: Main Gearbox, Hub, Main Frame, Shrink Disc, Lube System, Pitch & Yaw drives, Pitch & Yaw Bearings, Hydraulic System, Mechanical Brakes etc.

Design: R&D Centre in Germany & China.

Service: Experienced service engineers are available 24 x 7 at various wind farms, DHHI service team execute – Visual Inspection, Endoscopy Inspection, Vibration Measurement & Analysis, Oil Sampling & Analysis, Due Diligence, RCA, Retrofits, Replacements etc., Service Set up in India, Germany, Brazil & Australia.

Esteemed Customers: Wind Turbine OEM's, Independent Power Producers (IPP) & Independent Service Providers (ISP)

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

Target: Have a better future for next generation by providing more contribution to green energy business platforms worldwide.

DHHI

DALIAN HUARUI HEAVY INDUSTRY INDIA CO. PVT. LTD.

Address : 704, Surya Kiran Building, 19, K.G. Marg, New Delhi – 110001, INDIA | Tel.: +91-11-43504228

Mobile : 91-7042889767 | Email : info@dhhiindia.com

DALIAN HUARUI HEAVY INDUSTRY GROUP CO. LTD.

Address : No.169 Bayi Road, Xigang District, Dalian, China

Tel. : 0086-411-86428891

www.dhhiindia.com

Wind Energy Market, Technology and Role of Digitalization

Dr. Harpal Singh
Research Scientist
Tribology & Materials,
Sentient Science, Indiana
hsingh@sentientscience.com

Dr. Raj Shah
Director,
Koehler Instrument Company,
New York
rshah@koehlerinstrument.com

1. Market Update

The outlook for the global renewable energy is in the upswing. According to the global trends in renewable energy investment report, the investment in renewable energy is set to hit $2.6 trillion this year. Among various renewable energy sources, wind accounted for $1,023 billion in new energy investment over the past decade. Total investment over the past decade was roughly $2.6 trillion, with half dedicated to solar. China leads in global renewable energy capacity, investing about $758 billion between 2010 and early 2019. China was followed by United States ($356 billion), Japan ($202 billion) in the top three, whereas India is following closely at number 6 with an investment of $90 billion.

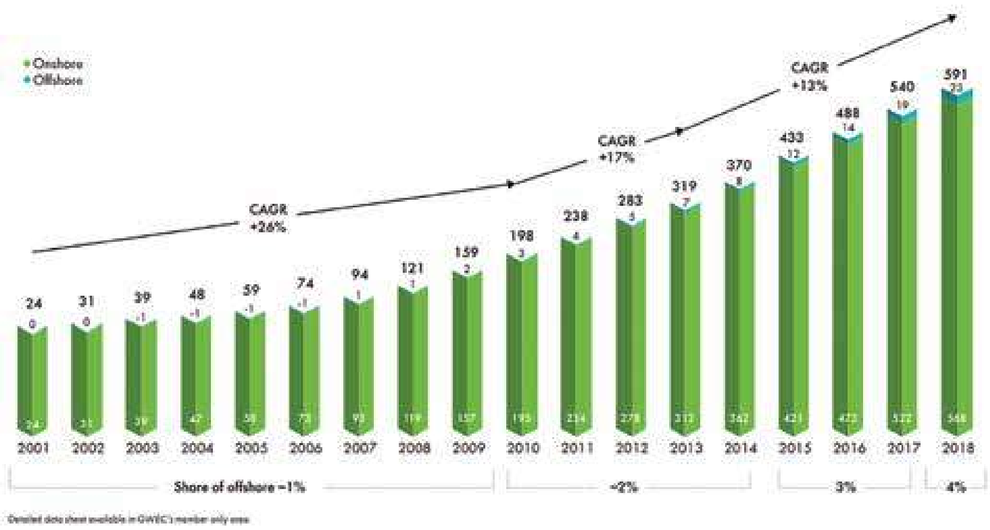


Figure 1: Historic Development of Wind Turbines (Source: GWEC report 2018)

The global capacity for generating power from wind energy has grown continuously since 2001, reaching 591 GW in 2018, according to the Global Wind Energy Council (GWEC), which publishes an annual report on the industry[5]. The total installation in 2018 on onshore was 568.49 GW, about half 256.32 GW of it was in Asia-Pacific only. In the Asia-Pacific, China leads in total installations with 208.804 GW, followed by India and Australia. In addition to exploiting land-based regions, many countries with ocean coastline are developing offshore wind power generation. The trends in offshore capacity mirror those for land-based capacity, showing steady growth. The global offshore capacity as of 2018 was 23.14 GW, or about 4% of the total global 2018 capacity of 591 GW according to the GWEC. Off-shore wind energy production is dominated by European countries. However in 2018, China installed 1.8 GW of offshore capacity, which is more than any other country in the world. India is an emerging offshore market as they held a first expression of interest in 2018, and their first offshore project is expected shortly.

The wind energy is expanding onshore and offshore with bigger and more powerful turbines that makes wind energy possible in areas with lower wind speeds. Moreover, the cost of onshore wind energy has become competitive with utility-scale solar photovoltaics and gas combined cycle generation, joining them as the three least expensive sources of energy. According to Lazard, a financial advisory and asset management firm, the cost of wind energy dropped 69% from 2009 to 2018 in the United States. The mean levelized cost of energy (LCOE) for wind power is now $29 to $56 per megawatt-hour. Coal is the only other technology that approaches the same range.

In a growing trend, large corporations in the US are including wind power in their power purchase strategy, either through direct ownership of wind projects or through purchase agreements. Among Commercial and Industrial purchasers (C&I), Walmart made an early mark in this area with a purchase announced in 2008, and Google Energy has announced purchases each year since 2010 and is currently the largest wind customer among C&I with a total contracted capacity of 1096 MW. According to the 2019 GWEC annual report, global wind power capacity is expected to increase by 50% in the next five years due to reduction in technology costs and emerging markets.

2. Wind Energy

Wind is basically an atmospheric air in motion. Wind spans a wide range of spatial scales, and wind speed varies globally and locally depending on the global circulation, geographical location, terrain, weather patterns, and more. A long list can be assembled of various wind types and names around the world. Wind when blows, it can move things depending on its velocity and density. The velocity of the air is related to the amount of energy in the wind, which referred to as the kinetic energy. Energy is captured from wind by wind turbine blades through the phenomenon of lift–the same phenomenon that allows birds and airplanes to fly (turbine blades are, in essence, captive wings). The lift generated as wind passes over the wind turbine blades causes it to move, thereby rotating the main shaft. The rotation is transmitted through a gearbox to a generator, which converts it into electricity. The amount of energy in a moving object depends on two factors, its mass and speed, therefore the energy of a moving object is as follows:

$$E = \frac{1}{2}mv^2 \tag{2.1}$$

This equation implies that if mass is doubled (mass = density x volume), the energy doubles and if the speed is doubled the energy is four times.

Wind and other moving fluids are better represented in terms of power. The kinetic energy from the wind velocity and air density flows into the area swept by the blades. Wind power quantifies the amount of wind energy flowing through an area of interest per unit time.

The mass flow rate of moving air with a density ρ through a cross-section area *A* is

$$w = \rho v A \tag{2.2}$$

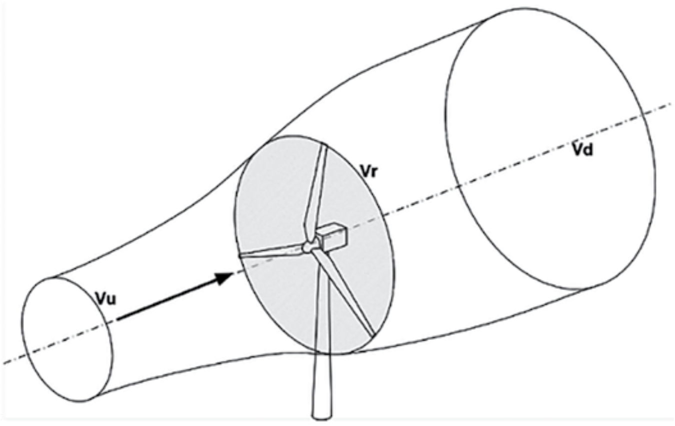


Figure 2: Wind Flow at Velocity v Through Area a Equivalent to Wind Turbine Blade

The power contained in a flowing mass of air through area *A* is

$$P_{wind} = \frac{dE}{dt} = \frac{1}{2}wv^2 = \frac{1}{2}\rho v^3 A \tag{2.3}$$

The power extracted by blades of diameter *d* is

$$P_T = \frac{\pi}{8}c_p \rho v^3 d^2 \tag{2.4}$$

The power coefficient c_p has a theoretical limit of ~0.59. This is referred to as the Betz limit, which defines the maximum amount of wind kinetic energy that can be converted to mechanical energy.

The power output of a wind turbine depends on 3 variables as seen in Equation 2.4: density of the air, wind speed, and rotor diameter. Wind speed and rotor diameter are two primary parameters due to the following:

- Turbine power increases with the square of blade length. For example, increasing the rotor diameter from 262 ft (80 m) to 394 ft (120 m) allows power to increase from 2 MW to 5 MW (a factor of 2.5).
- Turbine power increases with the cube of wind velocity. For example, a turbine at a site with an average wind speed of 16 mph would produce 50% more electricity than the same turbine at a site with average wind speeds of 14 mph.
- The efficiency of a wind power is quantified by the power coefficient, $C_{p.}$ Power coefficient is the ratio of power extracted by the turbine (P_T) to the total power of the wind resource (P_W).

$$C_p = \frac{P_T}{P_{wind}}$$

The Cp is multiplied by Equation 2.3, to calculate the actual wind turbine power as given in Equation 2.4, which is always smaller than the power of the wind. According to Betz theory, the maximum power possible from a wind turbine is 59%, meaning that 59% efficiency is the maximum power that can be extracted by a conventional wind turbine. Another key metric that reflects actual wind power generation is called capacity factor (CF). The capacity factor is the annual average of power generated divided by the rated peak power. For example, if a turbine rated at 5 MW produces power at an average of 2 MW, then its capacity factor is 40%. The capacity factor is in part a function of the wind conditions at the installed location and thus varies by region.

$$CF = \frac{P_{Actual}}{P_{Rated}}$$

Capacity factor is based on both the characteristics of the turbine and the wind resource. A given wind turbine design operates at a range of wind speeds, see Figure 3. The minimum wind speed at which electricity can be generated is called the cut-in wind speed, where below this wind speed the turbine cannot produce power because the wind does not transmit enough energy to overcome the friction in the drivetrain. At the rated output wind speed, the turbine produces its peak power (its rated power). The generated wind power increases with the cube power of the wind speed (see Equation 2.4) upto a certain value which is called rated power. The cut-out wind speed is the upper limit placed by the wind turbine manufacturers to prevent the damage to turbine beyond a certain speed.

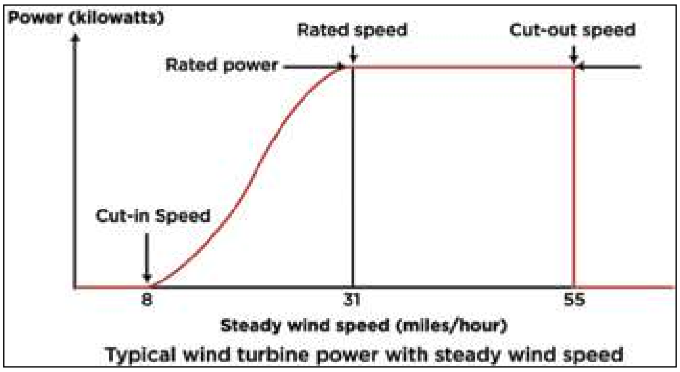


Figure 3: Wind Turbine Power Curve Highlighting Wind Turbine Operation at Various Speeds[8]

3. Wind Turbine Types, Components and Technology

Wind turbines are of many types. As they are most common, wind turbine configuration consists of a three-blade rotor. The most known versions of wind turbines are either of horizontal axis or vertical axis wind turbine. Vertical-axis turbines have two general designs. The Savonius design has scooped blades; in the Darrieus design the blades are flat. A Darrieus turbine doesn't have a good starting torque, so at low wind speeds it can't rotate. An advantage of the vertical axis is that blades do not have to be mechanically reoriented when the wind direction changes. Horizontal-axis turbines also come in two general designs. In a downwind design, the blades face away from the oncoming wind; in an upwind design, the blades face into the wind. Majority of currently installed turbines are of the upwind type as upwind designs avoid the wind shade behind the tower. Wind turbines vary in size, design and power output.

Wind turbines consist of many components, and the components are essentially same for most of the turbines. Here we are describing components of the most common three blade propeller type wind turbines. Figure 4 shows a simplified view of components of a three blades gearbox-driven wind turbine.

Wind turbines contain both mechanical and electrical parts. Wind turbines are equipped with control systems which comprise of mechanical, electrical, and/or hydraulic systems. There are three main sections to a three-blade wind turbine: the tower, the rotor blades, and the nacelle. The tower is what holds the rotor blades and nacelle high up in the sky, the height of which varies per turbine design. The rotors can vary in size, and are crucial to the efficiency of power output. The rotor blades capture wind energy from air and transfer it to rotational energy. The size and shape of the blades are designed in a way to extract maximum energy from the air and to achieve the best possible aerodynamic performance. The majority of the wind turbines currently in operation contain three rotor blades, as they more efficient in transforming wind energy into electricity. The nacelle is a housing which contains the gearbox, generator, brake assembly and drivetrain systems.

Wind Turbine Major Components	
Mechanical	Tower, Nacelle, Rotor, Gearbox, Brake
Electrical	Generator, Transformer, Anemometer, Vane, Rectifier

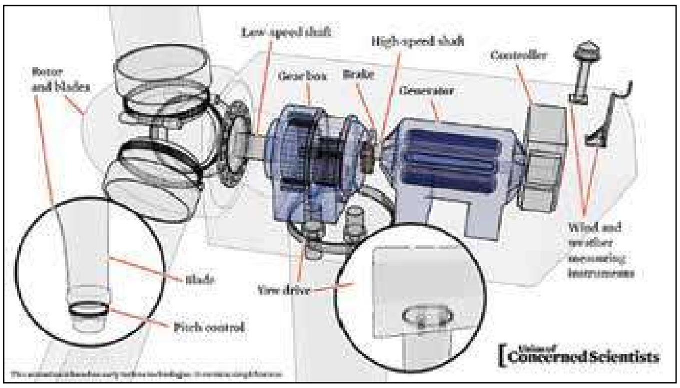


Figure 4: View of Components of a Gearbox Driven Wind Turbine. (Source: Union of Concerned Scientists)

The energy from the rotors is transferred to the main shaft connecting the gearbox, which is further connected to the generator, to generate electricity. The gearbox converts low speed input from the main shaft to high speed output to the generator. Figure 5 shows a typical three-stage wind turbine gearbox. A planetary stage (bottom left) transfers the torque first to a low-speed intermediate stage (bottom right), and then to a high-speed intermediate stage (middle), which drives a high-speed stage (top) that feeds the generator. Such a design might, for example, convert 14 RPM input from the rotors into 1500 RPM to the generator; the exact conversion of course depends on the gear ratio.

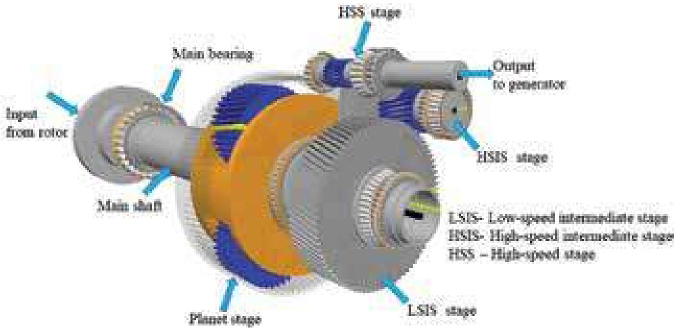


Figure 5: Power Flow Diagram of a Three-Stage Wind Turbine Gearbox. The Low-Speed Input from the Rotors (far left) is Converted into High-Speed Torque to the Generator (top right). (Courtesy of Sentient Science)

The generator located next in line to gearbox, as seen in Figure 4, converts the rotational energy from the high-speed output from the gearbox into electrical energy, which can then be transmitted into the power grid. There are many mechanical systems that compose the entire wind turbine, with numerous moving parts that oscillate, vibrate and rotate under high loads, and high and low speeds, such as the yaw, pitch, gearbox, and generator. The yaw drive turns the nacelle so that the rotor blades are always facing into the wind when it changes directions. The rolling motion occurs as the rotor blades rotate. The pitch controls the angle of the rotor blades such that the rotors meet the wind at an angle for optimum energy harvesting. Additionally, the pitch and yaw controls can be used as a safety control, to prevent the rotors from moving too fast.

Mechanical systems in wind turbines contain numerous tribological components such as bearings and gears to transmit torque, rotation, oscillation, which support the assemblies. For the drivetrain, in a gearbox-drive design, a gearbox is used to increase the speed transmitted from the rotors to the generator. Gearbox contains the highest number of gears and bearing among other systems in a wind turbine. Tribological components (gears and bearings) are lubricated for the efficient operation of a wind turbine. Lubricants are used to remove excessive heat from the contacting surfaces, provide resistance to wear, reduce friction, and to extend the durability of the components. Both greases and oils are used for various tribological components located in various systems. The wind turbine components that experience friction and wear and require lubrication are the following:

- Pitch bearing (grease)
- Main shaft bearing (grease)
- Gearbox if any (oil)
- Yaw drive (grease)
- Generator bearing (grease)

A wide range of bearings are used to perform different functions throughout a wind turbine. For instance, slewing ring bearings are typically used in pitch and yaw systems, to rotate the blades and turn the turbine towards the wind's direction. Figure 6 shows bearings of different types used in various locations within the wind turbine system.

Figure 6: Bearing Types Used at Various Locations in Wind Turbine Systems

So far we have discussed drivetrain loaded 3 blade wind turbines, which are typically used on land, often called land based turbines. Turbines which are located in a water body such as the sea are called off-shore wind turbines. There is new trend towards wind turbine platforms that are used off-shore. In general, off-shore installations are moving from gearbox to direct drive designs. In a direct drive design, rotor torque is directly transmitted to the generator, so there is no gearbox and the rotor is directly attached to the generator. The slow rotating speed of the generator is compensated by increasing the diameter of the generator. Offshore wind energy resources are available in abundance, and there is a growing trend towards larger multi-megawatt turbines to captures the off-shore wind energy resources. Without the need to limit noise or accommodate terrain-induced turbulence, designers can pursue truly giant scales. General Electric (GE) has built an off-shore design rated at 12 MW, significantly higher than the 2017 average of about 2.3 MW. It is indeed a giant: the rotor diameter is on the scale of the towers of the Golden Gate Bridge, and the surface area of the blade sweep is equivalent to seven American football fields. In this design, the torque is transmitted directly to the generator.

4. Failures in Wind Turbines

According to NREL, the highest number of downtimes is caused by gearbox issues, followed by generators, main shaft bearing and then by electrical systems, see Figure 7. Gearbox issues caused more than 150,000 hours of downtime as per NREL stats, which is significantly higher than any other system.

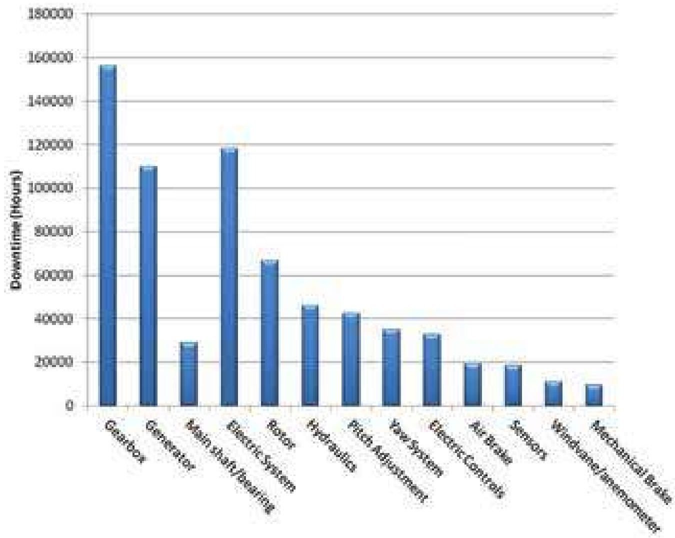


Figure 6: Downtime Hours in Wind Turbines by Failure of Components and Systems (Source: NREL)

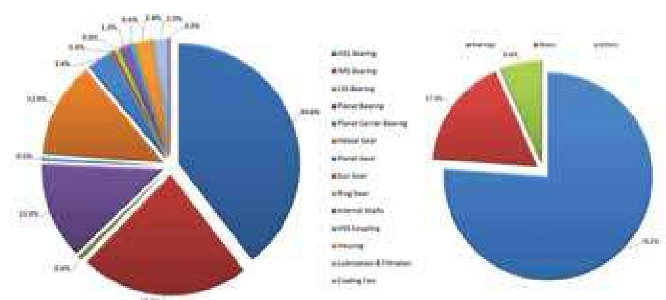


Figure 7: Failure Distributions among Various Components in a Wind Turbine (Source: NREL)

The major cause of gearbox failures is associated with bearings, followed by gears lubrication and wear. It is an important phenomenon that not only impacts the design and operation of wind turbine gearboxes, but also their subsequent maintenance requirements and overall reliability. With the major growth and increasing dependency on renewable energy, mechanical reliability is an extremely important issue. The Wind Turbine Tribology Seminar was convened to explore the state-of-the-art in wind turbine tribology and lubricant technologies, raise industry awareness of a very complex topic, present the science behind each technology, and identify possible R&D areas. To understand the background of work that had already been accomplished, and to consolidate some level of collective understanding of tribology by acknowledged experts, the National Renewable Energy Laboratory (NREL). According to the wind and water-power technologies office, the dominant factors for gearbox failure were 70% bearings, 26% gears and 4% others. Among bearings, highest failures were observed in high-speed shaft (HSS) or high-speed intermediate shaft bearings (HSIS), due to axial cracking and spalling caused by microstructure alteration known as white etching cracks in the bearing sub-surface. White etching cracks have been observed in martensitic, bainitic and case hardened AISI 52100 steel among others. 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. This means wind farm operators can readily incur costs ranging in the millions of dollars to deal with turbine failures.

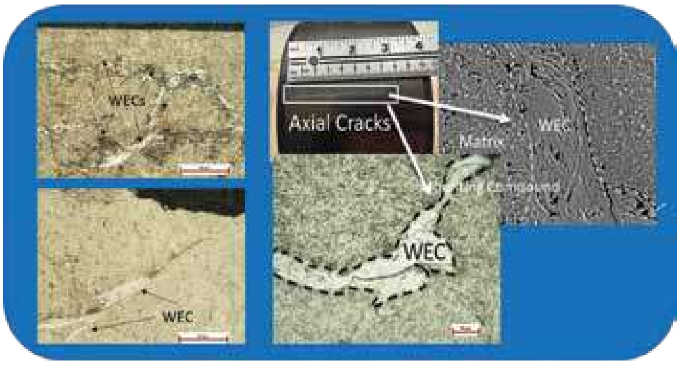


Figure 8: White Etch Crack (WEC) Appearance in Sub-Surface Microstructure When Observed Under Optical Microscope and SEM (Courtesy of Sentient Science)

The damage initiation for WEC begins at the weakest point, either near the surface or sub-surface, which develops with the increasing number of cycles to cause failures. The weakest point is either present as a material property in terms of defect (inclusions, voids, pores), weak microstructure due to poor heat treatment, residual stresses, or created by external factors such as impact loads, high sliding, stray currents, additives, corrosion and hydrogen. The development of the crack in the material microstructure can be accelerated by combining with other factors to cause failure. To account for various application conditions that cause premature bearing failures, stronger materials with improved bearing design are required. Case carburized bearings with at least ~20 austenite content are tougher than through hardened, considered to provide higher resistance to WEA formation. Retained austenite presence in the microstructure provides additional protection by reducing the overall diffusivity and permeability of hydrogen penetration in the steel. Black oxide (BO) surface treatment and carbon based coatings provide protection from micro pitting and other wear modes. These surface treatments also provide formidable barriers to the hydrogen permeation. However, the performance of these coatings and surface treatment depend on the composition, microstructure and structural integrity.

The high number of moving mechanical assemblies in the gearbox, main shaft, pitch system, and yaw systems require adequate lubrication for efficient operation of the wind turbines. The rotating components such as bearings and gears used in yaw, pitch, generator, and gearbox must be properly lubricated to increase reliability and to reduce wind turbine downtime. Unscheduled maintenance due to failures is especially troublesome in the wind industry, and there are significant efforts going on to increase the reliability of the systems. Reliability engineers and researchers use field data, experiments, and analytical techniques to determine the failure rates of products over time under specific conditions, and then work with design engineers to make robust components and systems. Reliability of wind turbines has improved over time, however further improvements are necessary to decrease downtime, maintenance cost, and the levelized cost of wind energy.

5. Digitalization

Digital twin, AI, and machine learning are buzz words these days in the wind industry. Digital twins involve creating a digital copy of the physical assets, processes and devices to allow remote monitoring and to reduce the levelized cost of energy through reduction in downtime and maintenance cost, while increasing production. Numerous multi-national corporations have embarked upon digitalization by investing heavily in digital technologies. Before going further, let's understand what digitalization is. Digitalization is the integration of digital technologies. The first step in digitalization is to digitize, where digitize is the conversion of analogue streams of information into digital bits.

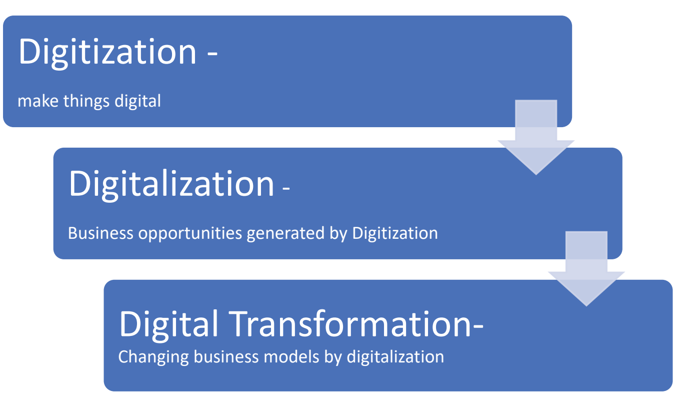


Figure 9: Road to Transformation through Digital Technologies (Source: DNVGL)

The main goal of digitalization is to improve efficiency. Companies are focusing to generate value out of data. Whether it is the wind farm developer or owner operators, the focus is to move away from spreadsheets, moving to organized digital visualization where you can extract more valuable information and draw bigger conclusions. Developers and operators are then not looking at just one site, but they are looking at the full fleet health state of any turbine. Digitalization makes it easier to track on how many units were replaced, which units needs repair and what inventory is available.

Technologies such as cloud infrastructure and data analytics make it possible to communicate and collaborate globally across time zones. Cloud computing makes data storage and access less costly and is more accessible. Internet connections are getting faster with the use of 5G technology, to analyze and process data anywhere in the world. The proliferation of data from the sensors is processed by algorithms such as AI and blockchain to access, visualize and interpret data. Digital applications to predict faults and to plan maintenance activities can help drive down LCOE.

The value of digitalization lies in using the data to understand the health condition of a wind turbine or a full fleet of turbines. The data provides valuable insight into when turbine maintenance is anticipated, so operator owners can plan their O&M in advance. In addition to improving reliability, digital models increase the annual energy production.

In the last decade, digital revolution has turned traditional industries inside-out by a two-sided digital platform. A two-sided platform is a digital marketplace that allows supply and demand to negotiate seamlessly. A simple example is of Uber and Airbnb. Within Uber, the driver and rider exchange the value as quickly as possible with little friction, while in Airbnb, a host and guest exchange the value for night accommodation. According to Sentient Science, two-sided platform is ideal for the wind industry to lower the cost and benefits for both sides. In the wind industry, the consumers are turbine fleet operators and the producers are OEM's and sub-components suppliers; both expect different benefits but their benefit are linked to the same asset – the wind turbine. In the approach taken by Sentient Science, the unit value is a 'life extension action". Life extension action helps maximize the life of a wind turbine by making intelligent, informed decisions concerning operations, maintenance, repair and repowering. Such a life extension action is defined in three parts: a market determined price and computationally derived life prediction associated with executing the action. The prediction states that if the action is taken, then a specific turbine, operating under specific conditions, will have its life extended by a specific, calculated amount of time. A two-sided platform drives much more than internal efficiency. In the wind energy industry, a two-sided platform holds promise for improving turbine lifetime by connecting turbine fleet operators with a broader pool of suppliers and maintenance options. This alone has the potential to improve efficiency and reduce costs throughout the supply chain.

Summary

The future of the wind energy industry is bright, as wind energy has been one of the fastest growing sources of renewable energy over the past decades. Global wind power capacity is

Emergya Wind Turbines in India offers 1 MW Direct Drive Technology Turbines DW61(Medium & Low Wind Site) & DW58 (High Wind Site) with Rotor Diameter of 61 & 58mts with Hub height of 69mts. We have our experience and expertise in Medium & Small-Scale wind energy projects with focus on Commercial, Industrial, Captive & Repowering customers.

The EWT Group with its headquarters in the Netherlands, is a manufacturer of direct drive wind turbines in the sub 1MW range, marketed under the brand name DIRECTWIND. EWT's vision is to be a driving force for a clean energy future by enabling companies and communities across the world to switch to renewable energy to cleanly and cost-effectively satisfy their energy needs. The EWT Group is active globally. Its head office is based in Amersfoort, the Netherlands

The combination of proven direct drive technology with Electrical Excited Generator and advanced control features makes EWT Direct Drive Wind Turbines a first-class choice for energy yield and reliability.

Emergya Wind Turbines Private Limited | (A Part of EWT Group)
SKCL Central Square 1, Ground Floor South Wing C-28 to 35, Thiru-vi-ka Industrial Estate, Guindy, Chennai | Tamil Nadu 600032, India

Please contact us for further Information on: Email: info.india@ewtdirectwind.com,
Website: www.ewtdirectwind.com, Telephone: +044 4560 4300, +91-7349615772

expected to increase by 50% in the next five to ten years due to reduction in technology costs and emerging markets.

Wind turbines produce power by the lift generated as wind passes over the wind turbine blades, causing it to move, thereby rotating the main shaft, which is connected to the gearbox and further to the generator. The power output of a wind turbine depends on 3 variables, density of the air, wind speed and rotor diameter. Turbine power increases with the square of blade length and the cube of wind velocity.

Wind turbines consist of many components, the components of which are essentially same for most turbines. Wind turbines are equipped with control systems which comprise of mechanical, electrical, and/or hydraulic systems. There are three main sections to a three-blade wind turbine: the tower, the rotor blades, and the nacelle. The tower is what holds the rotor blades and nacelle high up in the sky, height of which varies as per turbine design. The nacelle is a housing which contains the gearbox, generator, brake assembly and drivetrain systems. The highest maintenance cost in wind turbines is associated with gearbox failures. Majority of bearing failures are due to axial cracking and spalling caused by microstructure alteration known as white etching cracks in bearing sub-surface.

Numerous multi-national corporations have embarked upon digitalization by investing heavily in digital technologies. Digital revolution has turned traditional industries inside-out by a two-sided digital platform. A two-sided platform is a digital marketplace that allows supply and demand to negotiate seamlessly. A platform could advance the industry overall by removing technical and intellectual property barriers that prevent operators and suppliers from sharing data. With access to large quantities of field performance data, suppliers can design better components and gain a better understanding of failure modes.

References

1. https://www.ehn.org/renewable-energy-growing-2640193068.html
2. https://wwindea.org/information-2/information/
3. https://www.greentechmedia.com/articles/read/global-wind-power-capacity-to-grow-by-60-over-next-5-years#gs.19cjbv
4. https://www.earth.com/news/renewable-energy-investment-skyrocketed/
5. https://gwec.net/wp-content/uploads/2019/04/GWEC-Global-Wind-Report-2018.pdf
6. https://www.power-technology.com/comment/asia-pacific-will-lead-global-wind-turbine-market-into-2023-says-globaldata/
7. https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf
8. https://www.energy.gov/eere/articles/how-do-wind-turbines-survive-severe-storms
9. https://www.exponent.com/knowledge/alerts/2017/06/wind-turbine-reliability/?pageSize=NaN&pageNum=0&loadAllByPageSize=true
10. https://www.windpowerengineering.com/how-digital-twins-are-transforming-wind-operations/
11. https://www.nrel.gov/docs/fy17osti/67415.pdf
12. Singh, H., Pulikollu, R. V., Hawkins, W., & Smith, G. (2017). Investigation of microstructural alterations in low-and high-speed intermediate-stage wind turbine gearbox bearings. Tribology Letters, 65(3), 81.
13. Kotzalas, M.N., Doll, G.L.: Tribological advancements for reliable wind turbine performance. Philos. Trans. A. Math. Phys. Eng. Sci. 368, 4829–50 (2010).
14. Evans, M.-H.: White structure flaking (WSF) in wind turbine gearbox bearings: effects of "butterflies" and white etching cracks (WECs). Mater. Sci. Technol. 28, 22–3 (2012).
15. Sheng, S.S.: Gearbox Reliability Database : Yesterday, Today and Tomorrow. (2014).
16. http://www.stle.org/files/TLTArchives/2019/10_October/Webinars.aspx

Snippets on Wind Power

New Report to Help India Strategise Secure and Sustainable Energy Supply

India avoided 15% of additional energy demand, oil and gas imports and air pollution as well as 300 million tonnes of CO2 emissions between 2000 and 2018, according to a new report published by the International Energy Agency (IEA). India is becoming increasingly influential in global energy trends. The country's demand for energy is set to double by 2040, and its electricity demand may triple, according to report. Indian oil consumption is expected to grow faster than that of any other major economies. This makes further improving energy security a key priority for India's economy, says the report. The IEA welcomes Indian government policies designed to conduct large-scale renewable energy auctions, open up coal mining to private companies, and promote access to oil and gas markets for foreign investors. The report will help India to design implementation strategies to achieve secure and sustainable energy access for its citizens.

Source: Smart Energy International, January 13, 2020

Union Budget 2020-21

Power and Renewable Energy

Power and Renewable Energy

Budget Impact Positive

Key Budget Proposals

- Union Budget allocates Rs. 22000 Crores to Power and Renewable Energy Sector Ministry of New and Renewable Energy's budget hiked by 48% over the revised budget of fiscal 2020
- Rs 1,000 crore allocated for Kisan Urja Suraksha evam Utthan Mahabhiyan (KUSUM)
- Scheme to install solar projects along railway tracks announced
- Basic custom duty (BCD) levied at 20% for solar modules and cells
- New power generation companies included as manufacturing entities for corporate tax cut
- Smart metering and prepaid meters to be implemented across states by utilities
- Thermal plants not meeting emission norms to be shut down

Budget Impact

- Budgetary allocation hiked by 27% and 10% for wind and solar power, respectively, compared with the revised budget of fiscal 2020. This will help improve central financial assistance to schemes for solar rooftops, solar parks, off-grid renewable energy, etc.
- While the KUSUM scheme was announced in the previous budget, this is the first time a significant allocation has been provided. We expect this allocation to boost the scheme where implementation remains tardy.
- Installing solar projects along tracks translates to a potential 22-25 GW solar capacity addition (given 0.52 lakh hectare of vacant land with the Railways). Implementation will depend on location feasibility, power evacuation, and operation and maintenance-related challenges in the projects.
- 20% BCD on solar modules and cells will have a minimal impact as it replaces the existing safeguard duty of 15%. Further, the on-year decline in module prices means the impact on capital costs and tariffs for solar projects will be slight.
- Reduced tax rate of 15% coupled with the earlier reduction in Minimum Alternate Tax is a positive. We expect 80-100 basis points (bps) improvement in the equity IRRs (internal rate of return) of renewable companies and a 50-60 bps rise for conventional projects (for setting up of new capacities).
- Effective smart and prepaid metering implementation would improve:
  - Billing and collection efficiency, leading to a reduction in aggregate technical and commercial losses from the current ~21% (Source: UDAY portal).
  - Grid management and reduce the manpower requirement owing to digitalisation, helping discoms lower operating costs.
- The government proposes to close thermal power plants where the emission levels are higher than the prescribed limit. Based on CEA data, ~10 GW of thermal power plants could be impacted by this. This will help ease overcapacity in the sector to an extent.

Courtesy: CRISIL Budget Analysis

Snippets on Wind Power

MP Garners Investments worth Rs. 4125 Crore at WEF 2020 Davos

Madhya Pradesh has secured Rs. 4125 Crores in investments for 2 wind projects at the World Economic Forum (WEF) annual meeting in Davos. The state's Chief Minister Kamal Nath along with senior officials held discussions with potential investors and showcased the state as a viable investment destination. According to reports, the two wind projects of capacity 325 MW each are approved by the Soft Bank Energy (Japan) and Actis (England), respectively.

Source: PTI, January 24, 2020

India Becomes Second-Largest Market for Green Bonds with $10.3 Billion Transactions

India has become the second-largest market globally for green bonds with $10.3 billion worth of transactions in the first half of 2019, as issuers and investors continued to adopt policies and strategies linked to sustainable development goals, according to the Economic Survey 2019-20. A number of government agencies have contributed to this issuance including Indian Renewable Energy Development Agency (IREDA) and Indian Railway Finance Corporation (IRFC). In 2018, State Bank of India entered the green market with a $650 million certified climate bond.

We are working on a target to increase per capita consumption three times: R K Singh

Power and Renewable Energy Minister Mr. R K Singh today said on January 27, 2020 that his ministry is working on a target to increase the country's per capita consumption of electricity, a benchmark for economic well-being, three times over the current levels. Our per capita consumption of electricity is very low and is a third of the world average. According to International Energy Agency, India's per capita consumption of electricity in 2017 stood at 1.12 mega watt hour (mwh/capita), as against China's 4.55 mwh and the US's 12.57 mwh. Talking about the power sector's outlook, the minister said there is no room for entities making losses and no room for policies in the power sector which are not viable and sustainable.

Source: ET Energy World, January 27, 2020

India's Power Distribution Sector Facing Debt Pile of Over Rs. 4 Lakh Crore: ADBI

The distribution segment of India's power sector is experiencing a huge financial stress with debt amount touching a gigantic Rs 4.3 lakh crore, largely due to delayed payments, issues around tariff rationalization, and constraints emanating from subsidy disbursement, according to a working paper from Asian Development Bank Institute (ADBI), a policy think tank which provides intellectual input for policy makers in ADB's developing member countries. The policy efforts to restructure the debt of distribution companies (discoms) through the UDAY scheme do not appear to be producing the desired outcomes. Lately, it has become apparent that deep-seated malaise exists and that the solutions offered through schemes like UDAY are temporary and adhoc in nature," said the ADBI working paper A recent government survey has highlighted that more than 50 per cent of households in the country receiving less than 12 hours of electricity in a day as well as the poor per capita electricity consumption in the country stands at a meagre 1,149 kWh– which is one-third of the global average.

Source: ET Energy World, January 04, 2020

Indian Railways to Run 100% on Electricity by 2024

Indian Railways is eyeing full electrification of Indian Railways network across the country. Recently, at the India-Brazil Business Forum, the Railway Minister said that the country is embarking on rapid electrification of the railway network. By the year 2024, the Indian Railways' network will be 100 per cent electrified. Interestingly, Indian Railways will be the first railway in the world, of this size and scale, to be operated on electricity, the minister said. He also said that by the year 2030, the Railway Ministry plans to make the entire network of Indian Railways, a Net-Zero emission network. Thus, the national transporter will run on clean energy and clean power.

Source: Financial Express, January 28, 2020

PFC Gets $750 Million Foreign Currency Bonds Listed at NSE IFSC

State-owned power sector financier Power Finance Corporation (PFC) announced on 27th January 2020 the listing of $750 million foreign currency bonds on National Stock Exchange-International Financial Service Centre (NSE-IFSC), a wholly-owned subsidiary of National Stock Exchange (NSE).

This was the largest single tranche of international bond issuance by PFC, the country's largest state-run Non-Banking Finance Company (NBFC). Post the issuance, PFC's outstanding foreign currency borrowing portfolio has crossed $6 billion.

Source: ET Energy World, January 27, 2020

States Selling Renewable Power at Less than Rs. 3/kWh

The States of Karnataka, Tamil Nadu, Gujarat, Maharashtra, Rajasthan and Andhra Pradesh, with a combined capacity of 65.3 GW of variable renewable energy, are selling power at less than Rs. 3/kWh or $41.5/MWh. This could allow loss-making discoms of 'renewable-rich' energy States to earn new revenues and profits, and spare loss-making discoms of 'renewable-poor' States from investing in increasingly expensive new thermal generation capacity, providing a partial financial solution to the current dire state of discoms across India, according to the IEEFA report.

Source: The Hindu, January 13, 2020

Discoms Dues to Power Producers Rise by 45% to Rs. 81000 Crore

State-run electricity distribution companies' (discoms) dues to power producers stood at Rs 80,930 crore at the end of November 2019, up 45% from a year earlier. About 89% of these (Rs 71,673 crore) were "over-dues" with payment default of 60 days or more. The dues include those to independent power producers (about 30% of the total) and state-run utilities such as NTPC, DVC and NHPC. The trend of rising dues to power plants continues despite the Union Power Ministry implementing the letter of credit (LC) mechanism since August 2019 to compel discoms to become more disciplined in meeting payment obligations.

Rajasthan accounts for about 31% of total over-dues of discoms across India followed by Tamil Nadu and Uttar Pradesh for 16% and 18%, respectively. Discoms' financial losses stood at nearly Rs 28,000 crore at the end of FY19, up 88% y-o-y.

Source: Energystat, 13 Jan 2020

Power Ministry Launches Portal to Track States Energy Efficiency Performance

The Bureau of Energy Efficiency (BEE) under the aegis of the Power Ministry today released the State Energy Efficiency Index 2019, a portal that will track the progress of energy efficiency initiatives in all the states and union territories based on 97 indicators. Index incorporates qualitative, quantitative and outcome-based indicators to assess energy efficiency initiatives, programs and outcomes. The five key sectors studied under the index include buildings, industry, municipalities, transport, agriculture and discoms. New indicators for this year include adoption of Energy Conservation Building Code (ECBC) 2017, energy efficiency in MSME clusters, etc.

Source: Economic Times, 10 Jan 2020

India Needs 50 GWH of Battery Storage within 2.5 Years for Planned EV Transition: NITI Aayog Official

India will need 50 gigawatt hour (GWh) of battery storage capacity over the next two-and-a-half years to support the projected growth in renewable energy and meet the national electric mobility target, a senior NITI Aayog official said.

Source: Et Energy World, January 17, 2020

Spain Declares Climate Emergency, Signals Move to Renewables

Spain's new government on 21st January 2020 declared a "climate emergency" and pledged to unveil a draft bill on transitioning to renewable energy within its first 100 days in office. In a statement announced after the weekly cabinet meeting, the government committed to bringing a draft bill "to reduce greenhouse gas emissions with the objective of reaching climate neutrality by 2050" -- effectively net-zero carbon emissions. Prime Minister Pedro Sanchez's left wing coalition government, which took office on January 13, also committed to updating the national plan for tackling climate change.

Source: PTI, January 22, 2020

Envision Energy Commissions 2 Wind Projects in Gujarat

Envision Energy has commissioned two wind projects with a total capacity of 232.5 MW in Gujarat. The contracts involved a 197.5 MW wind power project for Actis-backed Sprng Energy and a 35 MW project for ReNew Power which were awarded under tranche 1 of Gujarat Urja Vikas Nigam's wind auctions. The projects were built on turnkey basis using 2.5-MW turbines with 131 m rotor diameter and 120 m hub height. The company also plans to soon introduce 3 MW class turbines with rotor diameters larger than 140 m and hub heights up to 140 m, suiting Indian wind and site conditions.

Source: PTI, January 24, 2020

Government Proposes Grant of Rs. 1.1 Lakh Crore for State Discoms

The government plans a grant of over Rs. 1.1 lakh crore to state power distribution companies under a new bailout scheme that would mandate discoms with high losses to either privatise operations or appoint distribution franchisees and invest in infrastructure upgradation, a senior official said. The government expects to spur about Rs 3 lakh crore of investments in the distribution sector through the latest discom restructuring scheme that it claims to be different from the three previous initiatives.

Source: ET Bureau, January 16, 2020

Western Rajasthan Produces Surplus Power, Thanks to Wind and Solar Energy

Winds of change in alternative power generation are sweeping across western Rajasthan with wind and solar energy producing surplus electricity for the tenth successive year considerably reducing greenhouse gas emissions. In Jaisalmer region, the total installed wind power capacity is 3933.52 MW and solar energy production is 113 MW, a senior official said.

Source: PTI, January 01, 2020

Standard Obstruction Markings and Lightings on Wind Turbines

At a meeting of Ministry of Defence it was informed by Indian Air Force authorities that the obstacle lights of several wind turbines are either damaged/not working which creates hazard for our aircrafts. Accordingly, it was requested to ensure the standard markings and serviceability of obstacle lights on all wind turbines, as per IS 5613 and International Civil Aviation Organization (ICAO) standards on Wind Turbines, on failing which the Ministry will be constrained to advise disconnection of such wind turbines from the grid. Accordingly, all OEMs/ wind farm developers/ Wind Farm operators were requested to submit a report regarding the operation of said lights on their wind turbines to MNRE.

The relevant clause is reproduced as under from the notification:

"Standard obstruction markings and lightings as per IS 5613 notification and International Civil Aviation Organization (/ CAO) standards as stipulated in ICAOAnnex-14 shall be provided by the company. The lights shall be kept 'ON' at al/times. Provision shall be made for standby power supply to keep the lights 'ON' during power failure. Company shall ensure standard markings and serviceability of obstacle lights in all weather conditions."

Source: MNRE Letter dated 1st January, 2020

India Needs Tariff Reforms to Boost Consumption of Renewables: WWF

As per a report by WWF-India, C&I consumers account for 51 per cent of the total electricity consumption in India, which is equivalent to 1,130 TWh per annum. "Concerted government action is required to grow penetration of renewable power for these consumers. There are two broad areas of action required. First, we need tariff reform to reduce financial dependence of discoms on C&I consumers. Second, new procurement models need to be enabled," said Bridge to India MD Vinay Rustagi.

Source: Economictimes.indiatimes.com, Dec 14, 2019

India Tops Clean Energy Investment Rankings Among Emerging Markets

In a first, India has topped the clean energy investment rankings among 104 emerging markets worldwide in a BloombergNEF survey, followed by India, were Chile, Brazil, China and Kenya, among the top five. The survey evaluated the ability of the emerging markets to attract capital for low-carbon energy sources while building a greener economy. "India's aggressive policy framework and copious capacity expansions propelled it to first place in 2019, from second in 2018.

Source: ET Energy World, January 23, 2020

Ceiling Tariff in Wind Energy Tenders to Go

In a move that could revive participation in wind bidding in a big way, the Ministry of New and Renewable Energy (MNRE) plans to stop imposing ceiling tariffs on wind tenders, according to sources close to the development. Recent wind and solar auctions conducted by the Solar Energy Corporation of India (SECI), an arm of MNRE, have all set 'ceiling tariffs' above which bids are not accepted. Removal of these ceilings has been a long standing demand of the industry. Developers have been protesting against them, maintaining that they are too low and are thereby restricting auction participation, and in turn the growth of renewable energy in the country.

Source: ET Bureau, 7th February 2020

Parliamentary Panel Pulls up MNRE for Missing Renewable Energy Targets Over the Years

The Parliamentary Standing Committee on Energy has pulled up the Ministry of New and Renewable Energy (MNRE) for failing to meet the targets for capacity addition over years. The failure could hamper the efforts at meeting the larger national target of reaching 175 GW capacity by 2022. It could achieve only 11,319 MW of grid-connected RE capacity addition against a target of 16,560 MW in 2016-17 and 11,876 MW of the targeted 14,445 MW in 2017-18. Similarly, during 2018-19, only 8,519 MW could be installed against the target of 15,355 MW, a shortfall of 44.50 per cent. For the current financial (2019-20), the ministry had managed to achieve 8004 MW of the targeted 11,802 MW grid-connected capacity by end January 2020. The country added wind energy capacity of 1981.51 MW between April 2019 January 2020 against the target of 3000 MW.

Source: ET Energy World, February 13, 2020

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

Know Our Member

About EWT India

Emergya Wind Turbines Private Limited (EWT India) is a part of the EWT-Group, headquartered in the Netherlands. EWT India was formed in June 2018 and is headquartered in Guindy, Chennai with an assembly factory located in Guduvanchery, Kanchipuram Dist of Tamil Nadu.

EWT India offers highly efficient 1MW Direct Drive Wind Turbines: the DW61 IEC Wind Class IIIA with a rotor diameter of 61 meters, for medium and low wind sites, and the DW58 IEC Wind Class IIA, with a rotor diameter of 58 meters, for high wind sites. The turbines have a hub height of 69 mts. and can be equipped with advanced grid support features like LVRT (Low Voltage Ride Through), AVT (Automatic Voltage Control), AFC (Automatic Frequency Control) and Reactive Power.

EWT has its experience and expertise in executing medium and small-scale wind energy projects with a focus on commercial, industrial, captive and repowering customers.

Emergya Wind Technologies-Group

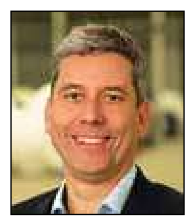
The Emergya Wind Technologies Group was founded in 2004 in the Netherlands and is active in India, United Kingdom, United States of America, Italy, Germany, Greece, France and the Netherlands. EWT is a global leader in the decentralised wind energy sector with wind turbines installed in more than 10 countries.

EWT's range of direct drive wind turbines with a rated capacity of up to 1 MW are engineered in-house by an international team of highly qualified engineers. EWT has a proven, certified, and high-performing product range for the decentralized wind sector, including features to assist integration with other sources of generation like diesel generators or solar PV.

EWT's operations have been externally accredited to meet ISO 9001 and OHSAS 18001 standards. All DIRECTWIND turbines have been type certified according to the IEC 61400 standard to ensure they function optimally during their planned lifetime.

Link: https://ewtdirectwind.com/turbines/direct-drive/

Directors Profile:



Mr. Renger Idema

The EWT-Group is headed by Mr. Renger Idema, appointed as Chief Executive Officer in 2018. Mr Renger joined EWT in 2008 and was appointed Chief Financial Officer and member of the Executive Board since 2012.

Mr. Mark Jonkhof

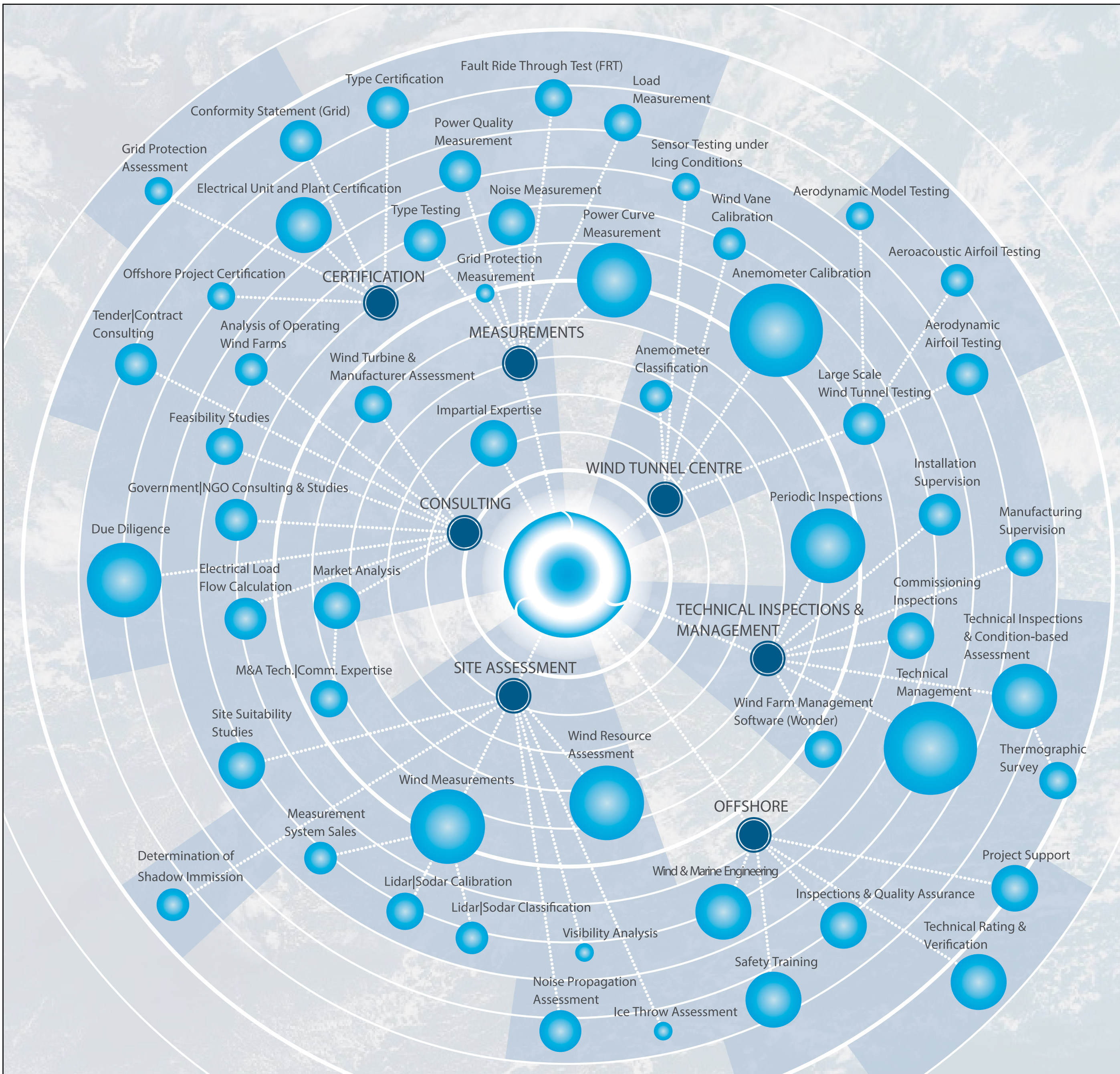
Mark Jonkhof joined EWT in 2015 as Chief Technology Officer. He started his career in 1995 at Philips Electronics in the field of industrial automation and manufacturing. In 2004 Mark switched to the Wind Industry and worked 11 years for General Electric before joining EWT in 2015.

Mr. Joshi R Raghavendra

The Indian & Asia operations of EWT are led by Mr. Joshi R Raghavendra, Director, India & Head of Business Development Asia. Joshi comes from a background of more than 16 years in the Energy Sector with the last 12 years in leadership roles in various renewable energy businesses.

Printed by R.R. Bharath and published by Dr. Rishi Muni Dwivedi on behalf of Indian Wind Turbine Manufacturers Association and printed at Ace Data Prinexcel Private Limited, 3/304 F, (SF No. 676/4B), Kulathur Road, Off NH 47 Bye Pass Road, Neelambur, Coimbatore 641062 and published at Indian Wind Turbine Manufacturers Association, Fourth Floor, Samson Towers, No. 403 L, Pantheon Road, Egmore, Chennai 600 008.

Editor: Dr. Rishi Muni Dwivedi


CERTIFICATION
Type Certification
Conformity Statement (Grid)
Grid Protection Assessment
Electrical Unit and Plant Certification
Offshore Project Certification
MEASUREMENTS
Fault Ride Through Test (FRT)
Load Measurement
Power Quality Measurement
Sensor Testing under Icing Conditions
Noise Measurement
Type Testing
Power Curve Measurement
Grid Protection Measurement
WIND TUNNEL CENTRE
Wind Vane Calibration
Aerodynamic Model Testing
Aeroacoustic Airfoil Testing
Anemometer Calibration
Aerodynamic Airfoil Testing
Anemometer Classification
Large Scale Wind Tunnel Testing
CONSULTING
Tender|Contract Consulting
Analysis of Operating Wind Farms
Wind Turbine & Manufacturer Assessment
Impartial Expertise
Feasibility Studies
Government|NGO Consulting & Studies
Due Diligence
Electrical Load Flow Calculation
Market Analysis
M&A Tech.|Comm. Expertise
TECHNICAL INSPECTIONS & MANAGEMENT
Installation Supervision
Periodic Inspections
Manufacturing Supervision
Commissioning Inspections
Technical Inspections & Condition-based Assessment
Technical Management
Wind Farm Management Software (Wonder)
Thermographic Survey
SITE ASSESSMENT
Site Suitability Studies
Wind Resource Assessment
Wind Measurements
Measurement System Sales
Determination of Shadow Immission
Lidar|Sodar Calibration
Lidar|Sodar Classification
Visibility Analysis
Noise Propagation Assessment
Ice Throw Assessment
OFFSHORE
Project Support
Wind & Marine Engineering
Inspections & Quality Assurance
Technical Rating & Verification
Safety Training

Registered with REGISTRAR OF NEWSPAPERS for India, New Delhi
Vide No. TNENG/2015/60605

December 2019 - January 2020
Date of Publishing: 17.02.2020

ACE DATA, Coimbatore