Indian Wind Power

Volume: 2 Issue: 1 April - May 2016 ₹ 10/-
Bimonthly, Chennai

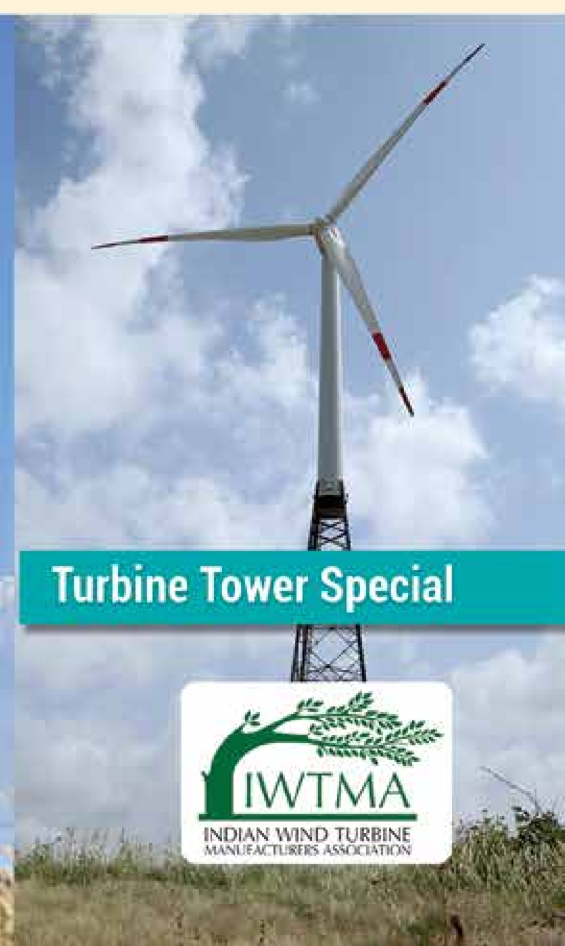
windergy INDIA 2017
WIND POWER FOREVER

IWTMA INDIAN WIND TURBINE MANUFACTURERS ASSOCIATION & GWEC GLOBAL WIND ENERGY COUNCIL

announce

WINDERGY INDIA 2017

Conference: 11th and 12th January 2017,
Exhibition: 10th, 11th and 12th January 2017
at The Ashok, New Delhi



Expertise offered to Wind & Solar Energy Stakeholders

Research & Development

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

Wind Resource Assessment

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

Testing Services

- As per Internationally accepted procedures and stipulations for
- Power Performance measurements
- Load measurements
- Power Quality measurements
- Safety and function tests
- Yaw efficiency test
- User defined measurements
- The services are not limited by type or size of the Wind Turbines
- The services are certified as per the requirements of ISO 9001: 2008 and accredited as per the requirements of ISO/IEC 17025 : 2005

Certification Services

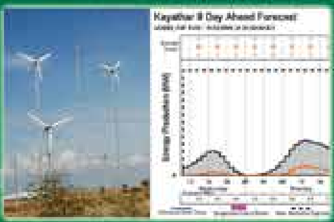
- Accord type approval / type certification to wind turbines in accordance with Indian Type Certification Scheme [TAPS - 2000 (amended)]. Type Certification Services are certified as per ISO 9001 : 2008
- Preparation of Indian standards on wind turbines
- Issue the Revised List of Models and Manufacturers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

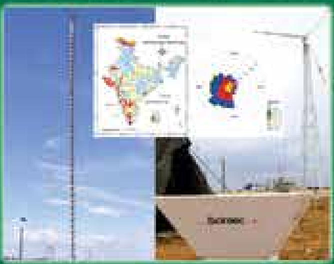
Training

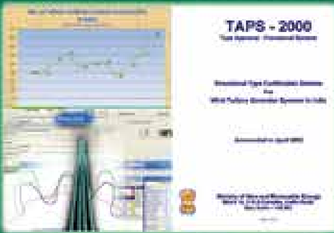
- Capable of providing
- Wind / Solar Resource Measurement & Analysis
- Wind Resource Modelling Techniques
- Wind Speed Statistics / Solar irradiation and Energy Calculations
- Micro-siting and Layout of wind / solar farms
- Wind Turbine / Solar Technology
- Design and Safety requirements as per standards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

Solar Radiation Resource Assessment

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







नीवे NIWE

NATIONAL INSTITUTE OF WIND ENERGY

Formerly "Centre for Wind Energy Technology"

An Autonomous Research & Development Institution, 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 http://cwet.res.in www.cwet.tn.nic.in E-mail : info@cwet.res.in

IWTMA
INDIAN WIND TURBINE MANUFACTURERS ASSOCIATION

Indian Wind Power

A Bi-monthly Magazine of Indian Wind Turbine Manufacturers Association

Volume: 2 Issue: 1 April - May 2016

Contents

Page No.

Key Highlights – Indian Wind Industry Analytical Scorecard (FY 2015-16) 3
Nitin V Raikar, Suzlon Energy Limited, Mumbai

Wind Turbine Tower Technology 6
D. Sreenivasan, Vice President, Operations, RRB Energy Limited

Parametric Optimization of Wind Turbine Towers 10
Dr. Rajesh Katyal, Deputy Director General and Head - Offshore, Small Wind, Hybrid Systems & Industrial Business, National Institute of Wind Energy (NIWE), Chennai – 600 100, TN, India

Wind Tower Technologies and Forthcoming Advancements 23
Bharathy K, Chief Executive Officer, Windar Renewable Energy Private Limited
kbharathy@windar-renovables.com

Wind Turbine Generators: The Evolution of Tower Technology 31
Vinod R Tanti, Chief Operating Officer (COO), Suzlon Group

Structural Analysis, Design and Field Testing of Wind Turbine Support Towers 33
P. Harikrishna, Sr. Principal Scientist; **A. Abraham,** Sr. Scientist; **S. Selvi Rajan,** Chief Scientist; **G. Ramesh Babu,** Principal Scientist, Wind Engineering Laboratory, CSIR-Structural Engineering Research Centre, Chennai

Snippets on Wind Power 38
Compiled By: **Mr. Abhijit Kulkarni,** Business Unit Head - Energy Segment, SKF India Ltd, Pune and **IWTMA Team**

Photo Feature 39

Know Your Member - ReGen Powertech Private Limited 40

Indian Wind Turbine Manufacturers Association

4th Floor, Samson Tower, 403 L, Pantheon Road, Egmore
Chennai - 600 008. Tel : 044 43015773 Fax : 044 4301 6132
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!

"With malice towards none, with charity for all, with firmness in the right as God gives us to see the right, let us strive on to finish the work we are in ...."

Second Inaugural address of Abraham Lincoln..........................

When I sat down to write out my first communication as Chairman of this prestigious Association, I was filled with mixed feelings - my delightfulness was overshadowed with the responsibility, all of us have and the trust that I had to hold in secure with all the stakeholders, including for the Government of India, which is exhorting all of us to make effective contributions to turn the plans of the Government into reality.

Let me again thank all my esteemed colleagues in the Association for their support and for the wishes received from across the country. Let us all try our best to keep up the momentum and tradition of my illustrious predecessors to come up to the expectations and aspirations of the stakeholders.

The wind industry has now created a record with an installation of 3414.65 MW in 2015-16. This surpasses the installation of 3197 MW in 2011-12. The state of Madhya Pradesh has set a record for itself of 1261.4 MW. It is a demonstration of proactive policy, which includes a tariff for a meaningful IRR, technology to harness wind energy under low and medium wind regime and interest cost prevailing rates. It is heartening that the wind energy share is 63% of the total renewable energy capacity of 42752 MW and 8.86% in total energy installation of 302 GW as on 31st March 2016.

In the Budget Speech of the Finance Minister in February 2016, there is an announcement of reducing the Accelerated Depreciation (AD) from 80 to 40% from the fiscal year 2017-18. It is further known of the sunset clause on the prevailing policy of Generation Based Incentive (GBI) that ends in March 2017. While this is not an encouraging note, as seen in 2011-12, the industry expects a rush in the year 2016-17 and one can fairly expects an installation base between 4000 to 4500 MW.

The question then is raised what happens thereafter from 2017-18? The answer is as follows:

a. Implementation of the Green Corridor Project for adequate evacuation;

b. Realistic transaction on interstate sale with rationalised STU charges;

c. De-bottling Open Access which would also help not so financially comfortable DISCOMs; and

d. Adherence to National RPO

The expected policy on repowering and tariff policy on wind solar hybrid would help to push the figures better. Furthermore, ease of doing business which includes land acquisition, permissions and approvals will attract investments from private equity, higher participation by PSUs and encouragement to this sector by home grown corporates. The key factor lies in the fact that this source requires no fuel or water and we need to spread the words like 'Evangelists' to fight the climate change and global warming similar to the call of Prime Minister for 'Swatch Bharat'.

It gives me immense pleasure to inform our readers that IWTMA in partnership with Global Wind Energy Council (GWEC), is organizing an International Conference and Exhibition in New Delhi on 10th, 11th, 12th January 2017. The event is by the industry and for the industry and we are confident that such events will bring all stakeholders under one roof and with one single purpose for all "together we can make it happen".

We are highlighting in our 13th issue our passage to the 3rd year of publication of Indian Wind Power magazine on the theme of Towers. Towers hold the entire turbine, which is dynamic at 100 Mtrs. height to withstand high wind velocity and hostile nature conditions with importance to safety and functionality over performance.

We invite your feedback, views and expectations on this issue.

Regards,

Sarvesh Kumar
Chairman

Key Highlights – Indian Wind Industry Analytical Scorecard (FY 2015-16)

Nitin V Raikar, Suzlon Energy Limited, Mumbai (rnitin@suzlon.com)

Key Pointers - India

- Capacity addition in FY 2015-16 was the highest in the annals of the Indian Wind Energy sector surpassing the record of 3196.90 MW set in FY 2011-12
- Commissioned capacity addition of 3472.40 MW in FY 2015-16 (as against 2311.80 MW in FY 2014-15)
- The industry attracted an investment to the tune of ~ 3.16 billion USD
- This represents an impressive increase of 50.20% over FY 2014-15
- Cumulative wind power capacity in India approaches 27 GW mark and stands at ~26.91 GW as on 31.03.2016
- Cumulative wind capacity constituted ~64% of India's total grid interactive renewable Energy capacity
- Cumulative wind capacity constituted ~9% of India's total installed power capacity from all energy sources
- Cumulative grid interactive wind power installations would translate to (on per annum basis)
  - Emission offset of ~58.16 million tonnes
  - Coal savings of ~42.43 million tonnes
  - Tentatively power ~14.58 million number of households

Key Pointers – States

- Madhya Pradesh records a historic capacity addition close to 1300 MW (1.3 GW)
- Telangana makes a debut in the wind energy space and records a maiden installed capacity of 77.70 MW solely powered by Suzlon turbines of make - S97 2100kW 120m Hybrid Tower
- Installations in 9 windy states with 5 states registering positive YoY growth rate

State wise capacity addition for FY 2015-16 with growth/de-growth percentage w.r.t. FY 2014-15 indicated by arrows.

State	FY 2015-16 (MW)	FY 2014-15 (MW)	Growth/ De-growth (%)
Madhya Pradesh	1291.90	454.30	↑184.3
Rajasthan	687.90	523.50	↑31.4
Gujarat	385.65	196.72	↑96.0
Andhra Pradesh	362.50	254.80	↑42.2
Karnataka	240.30	315.60	↓23.8
Maharashtra	220.65	386.70	↓42.9
Tamilnadu	197.40	186.35	↑5.9
Telangana	77.70	-	N.A
Kerala	8.40	-	N.A
Total	**3472.40**	**2317.97**	

Key Pointers – Original Equipment Manufacturers (OEM)

- Total no. of Original Equipment Manufacturers (OEMs) who added capacity: 15
- The top 6 OEMs (who added capacity exceeding 100 MW each) constituted ~95.70% of the total installed capacity –
  - Gamesa Renewable Pvt Limited
  - Suzlon Energy Limited
  - Inox Wind Limited
  - Regen Powertech Pvt Limited
  - Wind World (India) Limited
  - GE India Industrial Pvt Limited
- Top OEMs who have a cumulative installation base exceeding 1000 MW or 1GW in India –
  - Suzlon Energy Limited
  - Wind World (India) Limited
  - Gamesa Renewable Pvt Limited
  - Vestas Wind
  - Regen Powertech Pvt Limited
  - Inox Wind Limited
  - RRB Energy

Key Pointers – Product & Technology

- A total of 2035 WTGs of different make and type were installed and commissioned
- Average turbine size was 1.71 MW as against 1.50 MW in the preceding FY
- The country's tallest wind turbine @ 120m Hub Height (HH), Hybrid Tower was installed & commissioned on commercial scale basis by Suzlon in Rajasthan for Renew Power at site Bhesada Dist., Rajasthan
- Suzlon successfully proto commissions its new product – S111 mounted on 120m HH Hybrid Tower
- Gamesa debuts its G97 114 RD with maiden proto commissioning in Andhra Pradesh in April 2015
- RRB Energy debuts its Pawan Shakti (PS) 1800kW with proto commissioning in TN in April 2015
- INOX commissions its prototype 2000kW, RD 113m in Gujarat
- Classification by Drive Train Topology

Drive Train Topologies Share for FY 2015-16		
Drive Train Topology	% of total MW installed	% of total Nos. of WTGs installed
Geared Drive Train	85.15%	77.70%
Direct Drive Train	14.85%	22.30%

Key Pointers – Product Size & Range

Product Size for FY 2015-16			
Product Size (Range)		MW	% of total MW installed
"Small WTGs"	< 750 kW	59.25	1.71
"Megawatt"	< 751 - 1499 kW	213.50	6.15
"Mainstream"	< 1500 - 2500 kW	3189.15	91.84
"Multi MW Class"	> 2501	10.5	0.30
Total	3472.40	99.70	

Key Pointers – Investor Class Segmentation

Investor Class Segmentation for FY 2015-16		
Investor Class	MW	% of total MW installed
Independent Power Producers (IPPs)	2408.85	69.37
Corporate + Retail Investors	826.55	23.80
Utilities (State & Private)	150.00	4.32
Public Sector Units	87.00	2.51
Total	3472.40	

- Investors who added 100 MW plus in FY 2015-16
  - Renew Power (IPP)
  - Mytrah Energy (IPP)
  - Greenko Group(IPP)
  - Ostro Energy (IPP)
  - CLP (Utility)
  - Orange Group (IPP)
  - Continuum Energy (IPP)
  - Energon Power Resources Pvt Ltd (IPP)
  - Sembcorp Green Infra (IPP)
  - Tata Power Renewable Energy Limited (Utility)
  - Hero Future Energies (IPP)

Key Pointers – State-wise Cumulative Capacity addition as of 31st March 2016

Cumulative Capacity Additions in Key Wind States of India up-to Mar 2016			
State	Capacity additions upto Mar 2015 (MNRE)	Capacity additions FY 2015-16	Total Cumulative Capacity
	Figures in MW		
Tamilnadu	7455.2	197.4	7652.6
Maharashtra	4450.8	220.6	4671.4
Gujarat	3645.4	385.6	4031.0
Rajasthan	3307.2	687.9	3995.1
Karnataka	2638.4	240.3	2878.7
Madhya Pradesh	879.7	1291.9	2171.6
Andhra Pradesh	1031.4	362.5	1393.9
Kerala	35.1	8.4	43.5
Telangana	-	77.7	77.7
Others	4.3	-	4.3
Total	**23447.5**	**3472.4**	**26919.8**

Disclaimer

1. The information contained herein has been compiled and collated from grassroots MI sources but its accuracy and completeness are not warranted, nor are the opinions or analysis which are based upon it.
2. However the data is fairly accurate and is based on extensive reconciliation with relevant industry stakeholders.
3. The statistical data if presented or published by the relevant government agencies in due course of time, shall prevail in all eventualities.
4. The compilation makes minimal references to the names of OEMs and attempts to portray the generic industry scenario.
5. This compilation has been compiled in the personal capacity and shall not be construed as the views of the company/organization employing the author.

Researched, collated and compiled by
Nitin Raikar

RRB ENERGY 25 years SILVER JUBILEE

RRB ENERGY

keeping life alive through innovation

25 years of scintillating crusade in the wind-harvesting sector has given RRB Energy a status par excellence and made it a force to reckon with in the wind harvesting sector. They are also set to bring about the much-needed change in how we perceive & consume energy for a greener tomorrow. Their pioneering in-house R&D leads the market from the front & bolsters their credibility in the global market. A true awakening beckons, and they are paving way for it.

For future of wind harvesting, contact

Telephone: 91-11-40552222,
Website: www.rrbenergy.com
E-mail: pawanshakthi@rrbenergy.com

Wind Turbine Tower Technology

D. Sreenivasan, Vice President, Operations, RRB Energy Limited

Tower is one of the key and critical components in wind turbine generators. It is not only load carrying member but also load transferring member which helps the designer to optimize nacelle components. This carries the nacelle, rotor and hub at its top. These towers are to position the turbines in the best possible position to take advantage of the wind. Since rotor diameter and hub height are two parameters in human control, which influence energy cultivation depends on wind shear (variation of wind speed with respect to height), increase in energy, safety of turbine and people and finally economic factor decide the height and type of tower.

There are many different types of towers available in market namely steel tubular/conical tower which is predominantly used in India, lattice tower, concrete steel hybrid tower, split bottom section tower, concrete tower, vertical bolt joint tower, polygonal section tower, etc.

Each type of tower is having its own advantages depends on size the turbine, type of terrain, average wind velocity, turbulence level of wind in that wind farm, etc.

Towers are made from tubular steel, concrete or steel lattice. Different types of towers are used in wind industry based on size of the turbine. Tubular steel towers, lattice towers, or concrete towers are most suitable for large wind turbines and Guyed tubular towers are only used for small wind turbines (battery chargers etc.).

In India, tubular/conical tower is being used as a common type of tower and in recent days cement and hybrid towers are considered due to competitiveness in price and also constraint in transportation of towers in hilly terrain. Due to increase in rating of turbines in India, logistics of tower in future may be a biggest challenge due to length and weight of sections of towers. To overcome this difficulty, some wind turbine manufacturers already exploring possibilities of using split bottom sections which will allow the company to go for higher rating turbines even in challenging terrain.

Height of the tower is an important in design of HWAT because wind speed increases with height and taller towers are enable turbines to capture more energy and generate more electricity.

Different Type of Towers:

(i) Tubular Steel Towers

Most large wind turbines are delivered with tubular steel towers, which are manufactured in sections of 20-30 meters with flanges at either end, and bolted together on the site. The towers are conical (i.e. with their diameter increasing towards the base) in order to increase their strength and to save materials at the same time.

A diameter varying from approximately 4.5 meters at the base to 2 meters at the top, divided in 3 or 4 sections assembled at the wind farm (they are bolted together). The length of a section can vary from 20 to 30 meters. Basically they are manufactured with steel sheets cut, rolled and welded.

They are constructed from rolled steel plates welded together with flanges top and bottom, being sprayed with several coats of gray weatherproof paint at the construction yard. They have doors top and bottom allowing entrance to the vertical ladders inside used to access the power cables and the yaw mechanism. There are also a set of vertical ladders on the outside of the tower accessing the nacelle for maintenance and other checks.

(ii) Lattice Towers

Lattice towers are manufactured using welded steel profiles. It can be constructed with perfectly shaped steel rods that are put together to form a lattice. These towers are very strong and inexpensive to manufacture and easy to transport and erect.

Lattice tower were common in the past when turbine where smaller (less than a MW), but are seldom used today. Their biggest problems are a notable visual impact, and higher construction and maintenance costs. They have several advantages: they use less material (about 50% of a standard steel tower with the same stiffness) and they produce less shadow.

Advantage:

The basic advantage of lattice towers is cost, since a lattice tower requires only half as much material as a freely standing tubular tower with a similar stiffness. The basic disadvantage of lattice towers is their visual appearance (although that issue is clearly debatable). Be that as it may, for aesthetic reasons lattice towers have almost disappeared from use for large, modern wind turbines.

The new steel towers of more than 100 meters have a base section diameter over 5 meters, this can be a problem, because in many countries the maximum transportable size by road is less than 4.9 meters.

(iii) Tubular Concrete Towers

Concrete towers are a solution in countries were steel price is unusually high (for instance in Brazil, where steel production is almost a monopoly).

They are made of several smaller precast pieces assembled on site. This solution allows an easier transportation due to the smaller dimension of the components and a good control of the quality of the materials. The biggest problem is the weight (unless they are designed in a biggest number of pieces, they can weight more than the nacelle).

(iv) Guyed Pole Towers

Guyed pole towers are very strong and most economical when properly installed. But it requires more space around the tower for guy wires.

Many small wind turbines are built with narrow pole towers supported by guy wires. Fixed guyed towers are similar to tilt-up towers, except they are permanently fixed in place so you need to climb the tower to do any maintenance.

Advantage:

It is weight savings, and low cost.

Disadvantage:

Difficult access around the towers which make them less suitable in farm areas. Finally, this type of tower is more prone to vandalism, thus compromising overall safety.

(v) Tilt up Wind Towers

Tilt up towers are used for consume wind energy. These towers have locking system, while working the turbine is locked. It can easily lock and lowered to ground to perform repairs. Towers are held in position by four guy ropes one of which can be released, allowing you to lower the tower, so you can work on the turbine.

(vi) Hybrid Tower Solutions

Some towers are made in different combinations of the techniques. One example is the three-legged Bonus 95 kW tower shown in below image which may be said to be a hybrid between a lattice tower and a guyed tower.

Hybrid towers are another solution used by several manufacturer to reduce the exposition to the steel price volatility, the main drawbacks is that they are quite complicated to assemble so they have higher installation costs.

(vi) Free Standing Towers

These can be used for small wind turbines with cautions. Free standing towers have no guy ropes. As such they require a very solid foundation. Therefore these are certainly the most expensive, but may well be the most aesthetically pleasing.

Cost Considerations

Lot of research work is going on to make tower sections more sturdy and in the meantime with reduced weight. In near future we may not be surprised to have fiber glass or very special material tower sections which reduce weight of tower per MW by 50% from current level!!!

The price of a tower for a wind turbine is generally around 20 per cent of the total price of the turbine. For a tower around 50m height, the additional cost of another 10m of tower is about 15,000 USD. It is therefore quite important for the final cost of energy to build towers as optimally as possible. Lattice towers are the cheapest to manufacture, since they typically require about half the amount of steel used for a tubular steel tower.

Aerodynamic Considerations

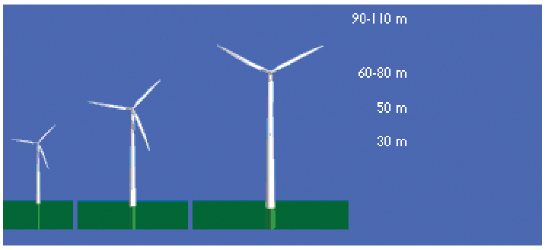
Generally, it is an advantage to have a tall tower in areas with high terrain roughness, since the wind speeds increases farther away from the ground, as we aware of wind shear. Lattice towers and guyed pole towers have the advantage of giving less wind shade than a massive tower.

Structural Dynamic Considerations

The rotor blades on turbines with relatively short towers will be subject to very different wind speeds (and thus different bending) when a rotor blade is in its top and in its bottom position, which will increase the fatigue loads on the turbine.

Comparison between Low and Tall Towers

Obviously, you get more energy from a larger wind turbine than a small one, but if you take a look at the three wind turbines below, which are 225 kW, 600 kW, and 1,500 kW respectively, and with rotor diameters of 27, 43, and 60 meters, you will notice that the tower heights are different as well.



Clearly, we cannot sensibly fit a 60m rotor to a tower of less than 30m. But if we consider the cost of a large rotor and a large generator and gearbox, it would surely be a waste to put it on a small tower, because we get much higher wind speeds and thus more energy with a tall tower. (See the section on wind resources.) Each metre of tower height costs money, of course, so the optimum height of the tower is a function of:

1. tower costs per metre (10 metre extra tower will presently cost you about 15,000 USD)
2. how much the wind locally varies with the height above ground level, i.e. the average local terrain roughness (large roughness makes it more useful with a taller tower),
3. the price the turbine owner gets for an additional kilowatt hour of electricity.

Manufacturers often deliver machines where the tower height is equal to the rotor diameter. Aesthetically, many people find that turbines are more pleasant to look at, if the tower height is roughly equal to the rotor diameter.

Occupational Safety Considerations

The choice of tower type has consequences for occupational safety, discussed in detail below.

Wind Turbine Tower Occupational Safety

Occupational Safety

Large, modern wind turbines normally use conical tubular steel towers. The primary advantage of this tower over a lattice tower is that it makes it safer and far more comfortable for service personnel to access the wind turbine for repair and maintenance. The disadvantage is cost.

The primary danger in working with wind turbines is the height above ground during installation work and when doing maintenance work. New Danish wind turbines are required to have fall protection devices, i.e. the person climbing the turbine has to wear a parachutist-like set of straps.

The straps are connected with a steel wire to an anchoring system that follows the person while climbing or descending the turbine.

The wire system has to include a shock absorber, so that persons are reasonably safe in case of a fall.

A Danish tradition (which has later been taken up by other manufacturers), is to place the access ladders at a certain distance from the wall. This enables service personnel to climb the tower while being able to rest the shoulders against the inside wall of the tower.

Protection from the machinery, fire protection and electrical insulation protection is governed by a number of national and international standards. During servicing it is essential that the machinery can be stopped completely. In addition to a mechanical brake, the rotor can be locked in place with a pin, to prevent any movement of the mechanical parts whatsoever.

Wind Turbine Tower Internal Ladder Risk for Falls and Falling Objects

With wind turbines being such tall structures, the risk for falls and struck-bys are an ever-present hazard on these sites. Throughout construction and maintenance efforts, workers may be required to climb ladders that place them hundreds of feet in the air. While most ladder falls in construction happen at a height of 10 feet or less, fixed ladders inside wind turbine towers extend far beyond the height of a standard ladder. When a fall does occur, workers may be more likely to suffer a serious injury or fatality. Contractors on wind turbine jobs must make fall prevention and protection a top priority and ensure they are protecting workers during all aspects of a fall.

Workers are also at risk for being struck by falling objects, loads and structures. Wind turbine construction involves using cranes and other lifting equipment to raise very heavy machinery hundreds of feet into the air. For example, the nacelle – the electrical gearbox at the top of the tower – can weigh about 90 tons.

Life inside the Wind Turbine Tower

Snippets on Wind Power

TNERC fixes RPO Obligations

TNERC has issued the amendment to the Renewable Energy Purchase Obligation Regulation, 2010 on 31.03.2016 and fixed the minimum RPO target of solar & non-solar as follows:

S. No.	Year	Minimum quantum of total renewable purchase obligation in percentage, in terms of kwh.	Minimum quantum of solar renewable purchase obligation in percentage.	Minimum quantum of non-solar renewable purchase obligation in percentage.
1	2015-2016	9.50	0.50	9
2	2016-2017	11.50	2.50	9
3	2017-2018	14.00	5	9

MERC issues final RE tariff order

Maharashtra Electricity Regulatory Commission (MERC) has issued RE Tariff order for the FY 2016-17, applicable from 1 April, 2016 to 31 March, 2017. The tariff for New Wind Energy Projects for FY 2016-17 are:

Wind Zone	Annual Mean Wind Power Density (W/m^2)	CUF	Levelised Tariff (Rs/Kwh)	Benefits of Tax and Additional Depreciation (if availed) (Rs/Kwh)	Net Levelised Tariff, adjusting for Tax and Additional Depreciation Benefit) (if availed) (Rs/Kwh)
Zone 1	<=250	22%	5.56	0.62	4.94
Zone 2	>250 - <=300	25%	4.89	0.55	4.34
Zone 3	>300 - <=400	30%	4.08	0.45	3.63
Zone 4	>400	32%	3.82	0.43	3.39

Tata Power Eyes 40% Renewable Energy Share

Tata Power has announced plans to increase its share of renewable energy output from 20% to 35-40% by 2025. The company currently has an installed capacity of 9,156 MW, including 593 MW from wind energy and 60 MW from solar power projects. Tata Power hopes to increase its installed capacity to 20 GW by 2025.

Parametric Optimization of Wind Turbine Towers

Dr. Rajesh Katyal, Deputy Director General and Head - Offshore, Small Wind Hybrid Systems & Industrial Business
National Institute of Wind Energy (NIWE), Chennai – 600 100, TN, India
Under Ministry of New and Renewable Energy, Govt. of India Katyal.niwe@res.in

Abstract: This article deals with parametric optimization of wind turbine towers. The aim is to analyze the various geometric configurations for 73 m tall wind turbine towers comprising of both lattice and tubular type. The wind turbine towers were analyzed using STAADPRO Tool to arrive at the most optimal/least weight configuration by changing the base dimensions. The top dimensions were kept constant as per the requirements for housing the nacelle at the top, within the limits of allowable blade deflection. As an outcome of the study the parametric relations between the base dimensions and bending moment at which least/optimal weight can be achieved both for wind turbine lattice and tubular towers are suggested. This will act as a ready-reckoner for tower designers specifically working for wind turbine applications.

Keywords: Wind turbine (WT), wind turbine tower, lattice tower, tubular tower, wind shear force, renewable energy and parametric optimization

1.0 Introduction

The wind turbine towers supports the high-tech and costly nacelle comprising of electro-mechanical components and sub-systems together with the rotor assembly. It provides necessary elevation to the nacelle to keep it off the ground and to bring it up to the level where the wind resources are available. Normally two types of towers are preferred for wind turbine applications viz. lattice and tubular towers. However, the concrete type towers are also sometimes used.

The lattice type of towers with bolted connection are basically designed and analyzed like a space truss. On the other hand, the tubular towers used for wind turbine applications are generally conical in shape; that is the diameters increase towards the base, thereby increasing their strength at the base where it is needed the most, because the load response owing to the wind loading is maximum at the base. The conical shape allows for saving in the material consumption. The maximum length of the tower sections is usually governed by the requirements to allow for transportation particularly in hilly/complex terrains due to improper Ghat roads/infrastructure requirements.

This article attempts in carrying out a parametric study both for wind turbine lattice and tubular towers which will foster the growth rate of wind turbine installations particularly suitable for complex terrains, in Indian context. The object of this article is to optimize an existing 73m tall lattice and tubular towers by choosing the various geometric configurations in terms of base dimension using STAADPRO Tool. The optimization used is a practical design office approach involving iterative analysis.

2.0 Generic Methodology/Approach Followed

2.1 Lattice Tower

The lattice structure basically behaves like a cantilever subjected to concentrated load/moments at the tower top hub due to wind shear and varying wind loads along the height of the tower. Due to the fixity at the bottom the moment at the base are the highest as it increases from the top to bottom and therefore higher width at the bottom is provided thereby tapering towards the top. The blades have a tendency of bowing/bending due to the action of the wind, the maximum deflection being at the tip of the blade and hence it needs to be ensured that the tip of the blade does not touch the body of the tower while passing by the side of the tower. This poses a restriction on the plan dimensions of the top segment of the tower having the height equal to the length of the blade. Hence the splaying of the tower can be designed only below the level of the tip of the down pointed blade.

2.2 Tubular Tower

The tubular tower supporting the wind turbine essentially behaves like a Cantilever, with minimum bending moment at the top and maximum at bottom. The force that causes the maximum bending moment in the tower is the Hub Shear, which is concentrated load causing a linearly varying bending moment. The wind load on the tower acts like a uniform distributed load along the height of the tower, which causes a parabolic distribution of bending moment. But the contribution of the bending moment due to the wind on tower is very small compared to the moment due to the hub shear. Thus the bending moment in the tower is closer to a linearly varying

Make the most out of your maintenance resources

Given the operating conditions a wind turbine faces over a typical 20-year service life, maintenance problems aren't a question of "if," but "when".

When inevitable maintenance problems occur, farms are faced with the prospect of exorbitant crane mobilization costs, lost energy production and soaring costs per kilowatt-hour. And to make matters worse, spare parts for wind turbines are very difficult to come by in this rapidly expanding industry.

SKF can help.

By enabling operators to monitor and track deteriorating component conditions in real-time, SKF solutions enable maintenance decisions to be based on actual machine conditions, rather than arbitrary maintenance schedules.

WindCon

Remote diagnostics centre

System24

WindLub

Remanufacturing of slewing bearings

Hybrid & INSOCOAT bearings

For these and more solutions, visit www.skf.com/wind or contact:

Abhijit Kulkarni
Head, Energy Segment, Industrial Markets, SKF India
abhijit.kulkarni@skf.com

Vinay Gaonkar
Manager, Application Engineering, Industrial Markets, SKF India
vinay.gaonkar@skf.com

The Power of Knowledge Engineering

SKF®

pattern than a parabolic pattern. Consequently it is logical that the shape of the tower follows the shape of the bending moment. The bending caused thus, is resisted by the internal stresses developed in the tower body. The stress developed due to a bending moment at any section is given by the equation:

$$\sigma_b = M / Z \quad (1)$$

Where M is the bending moment and Z is the section modulus at the section considered.

$$Z = \pi * d^2 / 4 * t \quad (2)$$

Where d is the mean diameter and t is the thickness.

From the above it is seen that for a given bending moment M, the stresses reduce as the square of the diameter, keeping thickness as constant.

Also, the allowable stress at a given section varies inversely with the h/d ratio. So larger the diameter, larger is the allowable stress. This is another reason for increasing the diameter towards the bottom. While the diameter towards to the top is tapered/reduced since the blades have a tendency of bowing/ bending due to the action of the wind. However the minimum top diameter has to be provided in order to accommodate the nacelle.

In the present study, the focus is to carry out the weight optimization by changing the base width for lattice type tower and base diameter for tubular type tower keeping the top dimensions (top width/top diameter) unchanged due the reasons described above. Accordingly the two models one for lattice type tower and another for tubular type tower with a height of 73m were developed and analyzed using STAAD Pro tool as shown in figures 1 & 2. Thereafter number of iterations was carried out by changing the base width in steps of 1m and by keeping the top width unchanged for lattice type tower. Similarly iterations were also carried out for tubular type tower by changing the base diameters in step of 0.25m and by keeping the top diameter unchanged. Also the other design parameters/loading conditions were kept same so as to arrive at the least/optimum weight both for lattice and tubular types of towers.

3.0 Configuration of the Towers

3.1 Lattice Tower

In the present study, a lattice type tower 73m height was modeled as described above with base width ranging from 12 to 18m. The iterations with varying base widths were carried out starting in steps of every 1m interval.

The lattice tower basically consists of main leg members, bracing members and secondary bracing members. The structure behaves like a cantilever structure, bending moment and the vertical load due to rotor assembly/blades, gear box and generator together with self weight of tower will be resisted by main leg members while the shear force is transferred by the bracings. The secondary bracings help in reducing the unsupported length of the legs/bracing members to reduce the buckling effect. The tensile/compressive force in the leg members due to the bending moment is inversely proportional to the distance between the legs. Thus by increasing the base width the force in the leg members will be reduced and hence the weight of the main leg members reduces thereby achieving the economy. However, by increasing the base width, the length of the bracing member increases, thereby increasing the weight of the bracing apart from reduction in its buckling strength and hence offsetting the economy achieved. Thus the aim was to examine the net effect in reduction of the weight and to arrive at the least/optimal weight for a given base width, other design configuration parameters being constant.

3.2. Tubular Tower

Similarly the tubular tower was modeled with base diameter varying from 3.5m to 5.5m in steps of 0.25m interval. The top diameter was kept constant at 2m. The bottom portion of the tower houses an access door opening of 0.6m x 2.0m was provided at a height of about 1m from the base for service

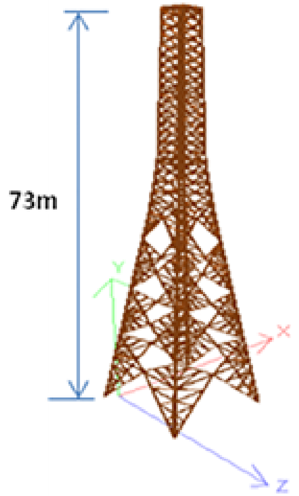


Figure 1: Lattice Tower

Figure 2: Tubular Tower

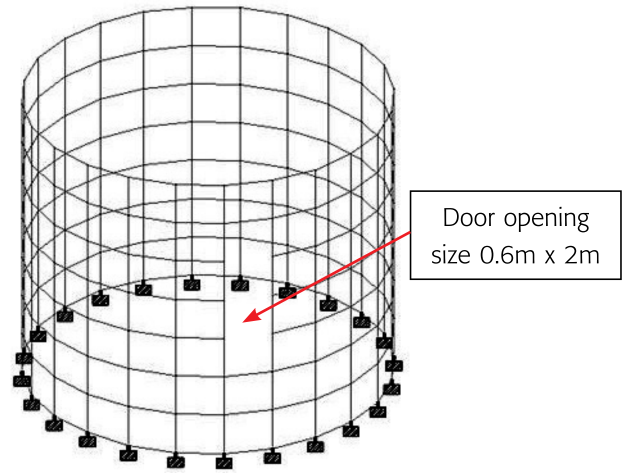


Figure 3: Cross section of 73m high tower with door opening

personnel to climb up to the Nacelle as shown in Figure 3. For this reason, the bottom 3.5m height of the tower has been considered as cylindrical. Beyond this, it starts tapering upwards up to height of 67 m from the bottom for 73m high towers. The 2.5m high portion above this up to the top was again kept cylindrical for housing the nacelle.

The structural data used for lattice and tubular type of tower is given below in Table 1.

Table 1: Structural Data for Lattice and Tubular Tower

Description	73 m WT Lattice tower	73 m Tubular tower
Type	Space	Space
Base width / diameter	Base width 12m (changing from 12 to 18m in steps of 1 m)	Base dia 3.5m (changing from 3.5 to 5.5 m in steps of 0.25 m)
Top width / diameter	Top width 2.6m	Top dia 2.0m
Height of tower	73 m	73 m
Number of nodes	352	3529
Number of elements	897	3500
Degree of freedom per Node	6 d.o.f.	6 d.o.f.
Total degree of freedom	2112	21174
Net degree of freedom	2100	21030

4.0 Modeling of the Tower

4.1 Lattice Tower

The main leg members for lattice tower were modeled using 3-D space truss while the bracings were modeled using 3-D beam elements. The bracings are modeled as beam elements in order to avoid instability problems. The legs are assumed to be hinged at the base the first model was developed based on the existing tower configuration with base width as 12 m and top width as 2.6m. The same was analyzed using STAADPRO tool and similar analysis was carried out for different models by changing the base widths. The typical 3-D view of the model is shown in Figure 4(a), and plans are shown in Figure 4(b).

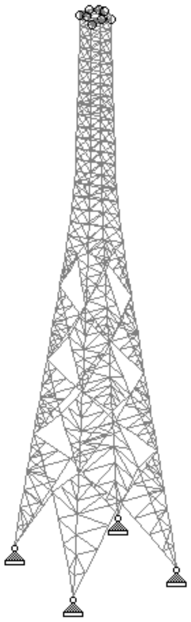


Figure 4(a): 3-D view of Lattice Tower

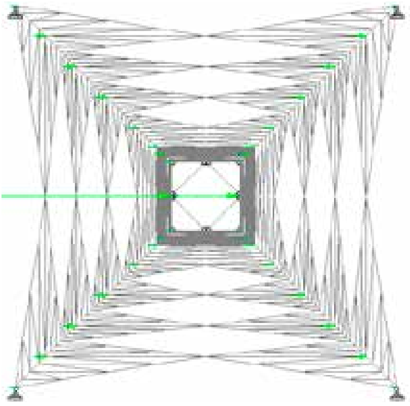


Figure 4(b): Plan view of Lattice Tower

4.2 Tubular Tower

The tubular tower resists the external loads applied in three ways: (i) Overall Bending, (ii) Local Bending and (iii) Compression. The first and second are caused due to the horizontal forces while the third is caused due to the vertical forces.

Any structure of this nature suffers two types of stresses due to the above actions namely,

i. In Plane Stresses
ii. Bending Stresses

Thus it is imperative that the element that is chosen to model the structure represents both the above said actions. STAADPRO has a four noded plate and shell element, which is a combination of Plane Stress Elements and Plate Bending Elements. The plane stress part consists of σx, σy & txy, where σx and σy are the normal stresses along X and Y respectively and txy is the plane shear stress. The Bending part consists of Mx, My, Mxy, Qzx & Qzy where Mx and My are the bending moments in the X – Z & Y – Z planes and Mxy is the twisting moment. Qx and Qy are the out of plane shear forces. Accordingly, the 73m tall tubular towers was modeled using four noded plate/shell elements.

The base of the tower was assumed to be fixed as the bottom plates are embedded in the concrete. Accordingly 24 base nodes were fixed and the tower was divided into 24 segments. The tower was meshed with an interval of 0.5m throughout the height of the towers. Care has been taken to keep the aspect ratio (i.e. the ratio for the sides) for the plates/elements to be kept less than 2. The first model was developed using the existing configuration with base diameter as 3.5m and top diameter as 2.0m. The same was analyzed using STAADPRO tool and similar analysis (static extreme wind) was carried out for different models by changing the base diameters. The typical 3-D view for the model is shown in Figure 5(a) and plans are shown in Figure 5 (b).

Figure 5(a): 3D view of Tubular Tower

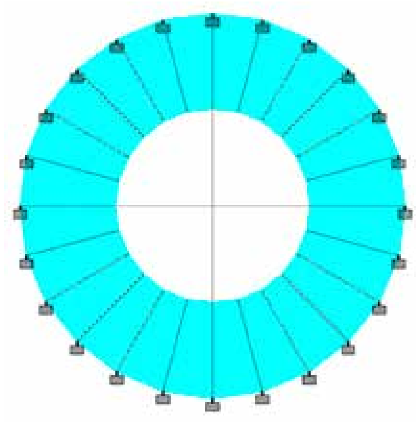


Figure 5(b): Plan view of Tubular Tower (showing 24 segments and fixity of the plates at the base)

5.0 Loads on the Tower

The three loads which are mainly acting on the top of the tower are hub level wind shear arising due to wind loading on the non-operating rotor, vertical load due to the self weight of the nacelle and moment due to the wind shear. Apart from this wind turbine towers is subjected to wind forces together with the self-weight acting along the height of the tower. The various loads acting on the tower are described in detail as under:

5.1. Hub Level Wind Shear Force

The hub shear force is calculated using the aero foil characteristics of the blades and the wind pressure. This value is normally provided by the wind turbine manufacturer and in the present study the hub level shear value of 29.6 tons has been worked out using the equation(5). The same is applied at the top of both lattice and tubular tower together with the moment of 119.1 Ton Meter, which is as a typical value for the wind turbine operating at this height as shown in figures 6 and 7, respectively.

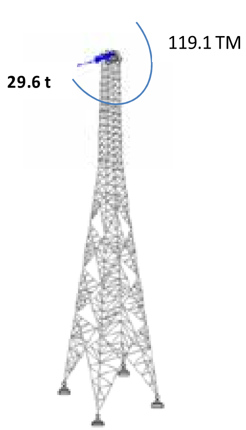


Figure 6: Hub Level Shear Force and Moment acting on Lattice Tower

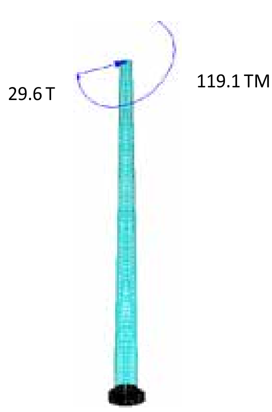


Figure 7: Hub level Shear Force and Moment acting on Tubular Tower

5.2 Vertical Load and Moment

The vertical load consists of self-weight of nacelle comprising of rotor assembly/blades, gearbox and generator mounted at the top of the tower. This load is also furnished by the manufacturer and is applied at the top four nodes of the tower and is shared equally assuming no eccentricity with respect to CG of the tower. While in case of tubular tower the vertical load is applied at the top center line of the tower assuming no eccentricity with respect to CG of the tower. Accordingly two intersecting Rigid Members (Beam Elements) have been modeled at the top of the tubular tower and the vertical loads are applied at the center of these beams.

The vertical load in this study was considered as 36 MT as shown in figures 8 and 9.

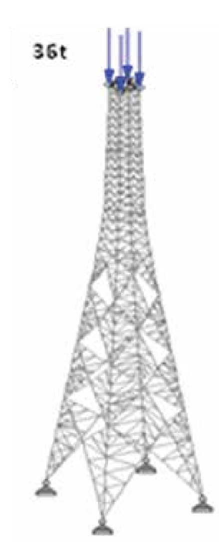


Figure 8: Vertical Load acting on Lattice Tower

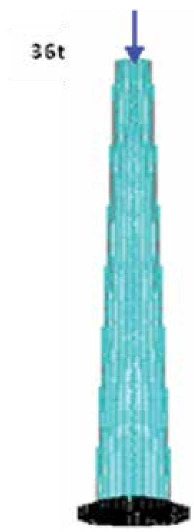


Figure 9: Vertical Load acting on Tubular Tower

5.3 Wind Load on Tower

The wind load on the tower was calculated strictly in accordance with IS 875-part 3 codal provisions. The basic wind speed for complex hilly terrain was considered 39 m/s. The risk coefficient (k1) was taken as 1.06 assuming the maximum life span of tower as 100 years. The terrain category (k2) was chosen as III with class C for obstructions closely spaced suiting to complex hilly terrains. The value of k2 for above conditions was chosen from the code in accordance with the height. The topography factor (k3) was chosen as 1.0 assessing absence of steep slopes or ridges/valleys. Using these values the design wind speed was calculated for different height along the tower using the relation:

$$V_z = V_b\, k_1 * k_2 * k_3 \quad (3)$$

The design wind pressure is given by the following relation:

$$Pz = 0.6\, Vz^2 \text{ where } Pz \text{ is } N/m^2 \quad (4)$$

While the hub level wind shear force is given by the relation.

$$F = P_z\, A_t * \varphi\, C_t \quad (5)$$

5.3.1 Lattice Tower

The lattice tower was sub divided into several panels and the exposed area (Ae) of each panel was calculated for the assumed size of leg and bracing members. The total area of the panel is calculated using trapezoidal formula:

$$A_p = (D_t + D_b)/2 * H. \quad (6)$$

Where

D_t - Top width

D_b - Bottom width

The solidity ratio (f) of the panel was calculated using the following relation:

$$\phi = A_e/A_p \quad (7)$$

The overall force coefficient (Cf) corresponding to the above solidity ratio was taken from the IS 875-part 3, Table 32 [13].

The total wind force on the panel is given by following relation:

$$F_p = P_z * A_e * C_f \quad (8)$$

The wind forces were calculated for various iterations. The wind force acting on each panel for lattice tower (base with 14m) is detailed in Table 2.

Table 2: Wind Forces acting on each Panel

Sl. No.	Levels	Panel ht	Bottom width	Length of Leg Member	Length of Bracing Member	Bracing angle (m)	Leg angle (m)	Drag Co-Efficient	Wind Pre-sure (Kg/m²)	Total Panel Force (Kgs)	Force on Each Panel(Kgs)
7	73.00	12.040	2.585	12.060	3.410	0.10	0.40	1.74	117.54	3067.80	383.48
6	60.952	10.740	3.098	10.750	3.850	0.10	0.40	1.82	117.54	3136.11	775.49
5	50.212	9.100	3.557	9.220	4.920	0.10	0.40	2.22	117.54	3175.63	788.97
4	41.112	10.278	5.011	10.520	5.720	0.10	0.40	2.86	117.54	3368.37	818.00
3	30.834	10.278	7.250	10.530	6.290	0.10	0.40	2.82	117.54	4676.95	1005.67
2	20.556	10.278	9.500	10.520	7.000	0.10	0.40	3.06	117.54	4294.49	1121.43
1	10.278	10.278	11.740	10.530	12.440	0.10	0.40	3.10	117.54	3498.00	974.07
0	0.000	0.00	14.000	0.000	0.000	0.10	0.40				437.25

The above wind force is distributed to the 8 nodes of the said panel equally. Figures 10(a) & 10(b) indicates the wind force being applied at each node both for 3-D and plan view.

The wind loads obtained from the above procedure are applied as nodal loads on the model and the analysis is performed.

It is found that the leg forces increase when the wind is blowing along the diagonal direction to take care of this the leg forces obtained for the face wind condition are multiplied by the factor of 1.7.

5.3.2 Tubular Tower

In case of tubular tower for calculating the wind loads, the tower has been divided in to 28 segments. The center of the segment is located along the height and the value of k2 is

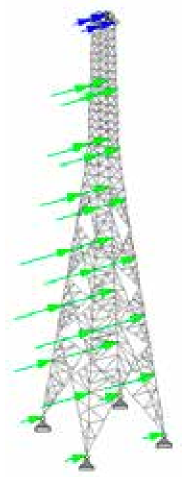


Figure 10(a): Wind Force Lattice Tower (3-D view)

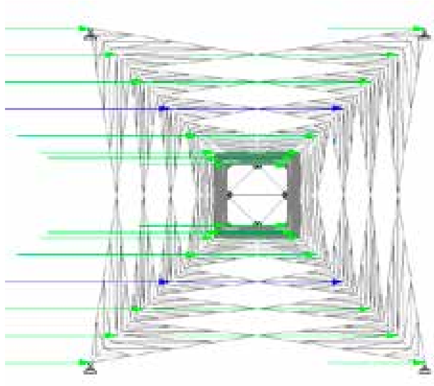


Figure 10(b): Wind Force Lattice Tower (plan view)

obtained from the Table given in IS 875-part-3 and the wind pressure at this location is calculated using equation(4) above. For determining the total wind load acting on the segment the mean diameter for each segment is calculated and is multiplied by the height of the segment, wind pressure and its shape factor as given by the following relation:

$$\text{Wind Force (F)} = 0.7 * Pz * D.\ h \quad (9)$$

Where D is the average diameter of the panel, h is height of the panel and shape factor is considered as 0.7.

The wind loads acting on the different segments for 73m tubular tower are shown in Table 3 below.

Table 3: Wind Loads acting on the different segments

Level at top of panel	Level at bottom of panel	Ht. of the panel (h)	k_2	Wind pressure Pz = 0.6*Vz2 t/m2	WF acting at (m)	Dia. @ the Section	Dia where force acts	WF = 0.7 * Pz * D. h (T)
73.00	70.500	2.5	1.168	0.140	71.750	2.000	2.000	0.49
70.500	68.000	2.5	1.165	0.139	69.250	2.000	2.037	0.50
8.00	65.500	2.5	1.162	0.138	66.750	2.075	2.112	0.51
65.50	63.000	2.5	1.159	0.138	64.250	2.149	2.187	0.53
63.00	60.500	2.5	1.156	0.137	61.750	2.224	2.261	0.54
60.50	58.000	2.5	1.153	0.136	59.250	2.299	2.336	0.56
58.00	55.500	2.5	1.150	0.136	56.750	2.373	2.410	0.57
55.50	53.000	2.5	1.147	0.135	54.250	2.448	2.485	0.59
53.00	50.500	2.5	1.144	0.134	51.750	2.522	2.560	0.60
50.50	48.000	2.5	1.141	0.133	49.250	2.597	2.634	0.62
48.00	45.500	2.5	1.135	0.132	46.750	2.672	2.709	0.63
45.50	43.000	2.5	1.129	0.131	44.250	2.746	2.784	0.64
43.00	40.500	2.5	1.123	0.129	41.750	2.821	2.858	0.65
40.50	38.000	2.5	1.116	0.128	39.250	2.896	2.933	0.66
38.00	35.500	2.5	1.110	0.126	36.750	2.970	3.007	0.67
35.50	33.000	2.5	1.104	0.125	34.250	3.045	3.082	0.67
33.00	30.500	2.5	1.098	0.124	31.750	3.119	3.157	0.68
30.50	28.000	2.5	1.091	0.122	29.250	3.194	3.231	0.69
28.00	25.500	2.5	1.084	0.121	26.750	3.269	3.306	0.70
25.50	23.000	2.5	1.077	0.119	24.250	3.343	3.381	0.70
23.00	20.500	2.5	1.069	0.117	21.750	3.418	3.455	0.71

Level at top of panel	Level at bottom of panel	Ht. of the panel (h)	k_2	Wind pressure Pz = 0.6*Vz2 t/m2	WF acting at (m)	Dia. @ the Section	Dia where force acts	WF = 0.7 * Pz * D. h (T)
20.50	18.000	2.5	1.062	0.116	19.250	3.493	3.530	0.71
18.00	15.500	2.5	1.048	0.113	16.750	3.567	3.604	0.71
15.50	13.000	2.5	1.033	0.109	14.250	3.642	3.679	0.70
13.00	10.500	2.5	1.014	0.105	11.750	3.716	3.754	0.69
10.50	8.000	2.5	0.994	0.101	9.250	3.791	3.828	0.68
8.00	5.500	2.5	0.974	0.097	6.750	3.866	3.903	0.66
5.50	3.500	2.0	0.954	0.093	4.500	3.940	3.970	0.52
3.50	0.000	3.5	0.938	0.090	1.750	4.000	4.000	0.88
0.00						4.000		

Figure 11 indicates the various load combinations acting on 73m tubular tower comprising of hub shear force, vertical load together with self-weight and moment acting on top of the tower and wind pressure acting along the height of the towers.

Figure 11: Various Load combinations acting on Tubular Tower

6.0 Analysis of Tubular Tower

For the purpose of analysis the tower has been divided into six segments. The analysis was carried out for the above load configuration using STAADPRO and the plate stresses obtained. The minimum and maximum plate stresses for optimized 73m high tubular tower and with base diameter as 4.5m is detailed in Table 4 below.

Table 4: Plate Stresses as obtained from STAADPRO

Sl. No.	Segment / Height of segment for 73m high tower	Plate stresses for 73m Tower	
		Min. N/mm²	Max. N/mm²
1	Segment-I (0-3.5m)	7.9500	105.1760
2	Segment-II (3.50-20.25)	7.8060	104.4760
3	Segment-III (20.25-37m)	13.0095	104.2680
4	Segment-IV(37 - 53.75m)	10.9615	86.4707
5	Segment-V(53.75-70.5m)	4.5700	67.3130
6	Segment-VI(70.05-73m)	9.8800	118.1830

The same was validated using a hand calculation procedure and then combined vertical stress obtained from STAADPRO almost matches with the hand calculation values.

6.1 Stress Concentration near the Door Opening for Tubular Tower

The vertical combined stress flow gets obstructed due to the presence of an opening and hence there is a concentration of stress flow around the opening. This causes a phenomenon called as "Stress Concentration" due to which the stress levels shoot up, whose consequences can be detrimental/serious. This cannot be predicted by hand calculation methods. However, a finite element method gives realistic estimate of stresses, so that the plate sizing can be done to cater to such stresses. The plate stress contours showing the stress concentration are shown for the bottom most segment of the optimized tower for 73m as shown in Figure 12.

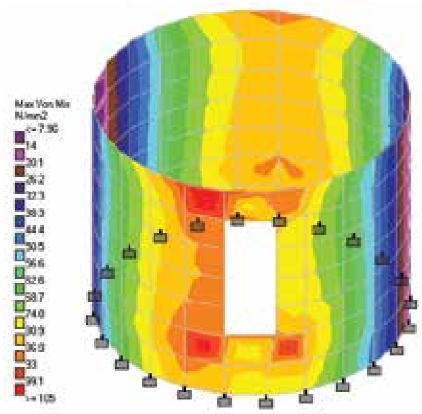


Figure 12: Plate stress contours showing the stress concentration at bottom most segment for 73m Tubular Tower

7.0 Design of Tower

7.1 Lattice Tower

Having obtained forces in each leg as well as bracing members the members are designed for both compression and tension as per IS 800 codal provisions. In case the member was found to have higher factor of safety [FS] the size of the member was reduced and in case it was found to be failing the size of the member was increased and the program was re-run for ensuring that all the members are passing.

7.2 Tubular Tower

For design purposes, the tubular tower has been divided into 6 segments. The thickness is maintained same throughout the height in each of the segments. The maximum vertical stresses from STAAD Analysis are obtained for each of the segments. The allowable stresses are obtained from IS 6533 by considering the tower as a tall chimney. Different segments are considered and the h/d ratio of the segment is calculated. For this value of the h/d ratio, the allowable stresses are obtained from the Table given in IS 6533. These are compared with the actual stresses and if it is found that the actual stresses are more than the allowable stress, the thickness is increased and a re-analysis is carried out. This process is continued till all the elements "pass". For this configuration the total steel take off/weight is calculated. Thereafter the repeated iterative analysis by changing the base diameter of the tower and keeping the other parameters unchanged is carried out and the steel take off/weight is calculated for each analysis.

8.0 Estimation of Empirical Relation between Base Dimensions and Bending Moment

In order to suggest the empirical relation between the optimized base dimensions and bending moment both for lattice and tubular towers (73m high), further iterative analysis was carried out using the varying wind shear force acting at the top. Accordingly, the hub level wind shear force was varied from 30MT to 50MT in steps of 5MT interval. For each value of wind shear force three iterative analysis was carried out both for lattice and tubular towers by varying the base dimensions and keeping all other parameters as constant. In case of lattice tower the iterative analysis was carried out by changing the base width in steps of 0.5m interval so as to attain the optimized/ least weight. While for tubular tower the iterative analysis was carried out by changing the base diameters in steps of 0.1m interval so as to attain the optimized/least weight. The bending moments for each optimized width and diameter for varying wind shear force was determined both for lattice and tubular tower, respectively. The objective was to determine the preliminarily values of the base dimensions, which provides the minimum cost of the wind turbine towers.

9.0 Results and Discussions

9.1 Lattice Tower

The seven different models with base width changing from 12m to 18m in steps of 1 m interval were developed and was analyzed for same loading conditions viz. wind shear force, vertical loads and moment for 73 m lattice tower. The total weight of the tower/steel take off for different base width was determined as indicated in Table 5.

Table 5: Steel take-off for various Base Widths (73 m Tower)

Models	Base width(M)	Weight/Steel take off (MT)	Height / Base
1	12	50.48	6.08
2	13	47.858	5.62
3	14	47.58	5.21
4	15	48.202	4.87
5	16	62.207	4.56
6	17	63.627	4.29
7	18	74.129	4.06

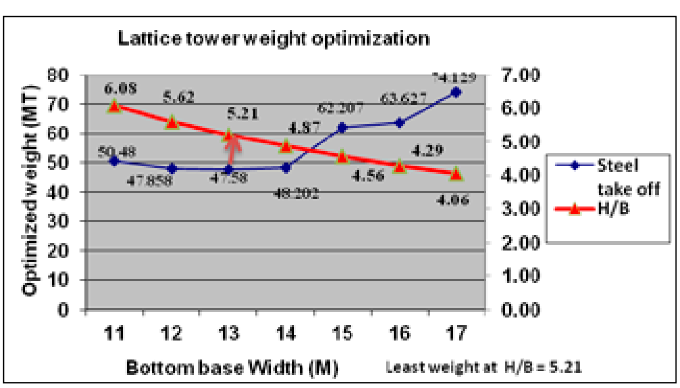


Figure 13: Variations of Steel take off with varying Base Width (for 73m) Tower

Figure 13 indicates the variation of total weight/steel take off with respect to the base width for both 73 lattice tower. It was concluded that for 73 m tower the base width corresponding to the least weight was 14m. A similar exercise was carried out for 30m height tower also. For both the cases the ratio of the height of the wind turbine to the base width works out to about 5 to achieve the least/optimized weight.

9.1.1 Parametric Relation between Base Width and Moment for Wind Turbine Lattice Towers

In case of wind turbine lattice towers the base width at the foundation concrete level is distance between the centre of gravity at one corner leg and the centre of gravity of the adjacent corner leg. Hence, there is a particular base width which gives minimum cost of the wind turbine lattice tower. For the said least weight base width, the bending moment at the base of the tower was obtained for varying hub level shear forces as detailed in Table 6.

Table 6: Base Width and Moment for varying Wind Shear Force (73m tower)

Sl. No.	Hub level Wind Shear force	Sqrt. of moment at the base of the tower (√M)	Optimized base width
	(MT)	(TM)	(M)
1	30	53.516	14
2	35	58.08	14.5
3	40	61.29	15
4	45	64.40	15
5	50	67.479	15.5

Figure 14 indicates the best fit straight line between optimized base width and moment at the base for 73m lattice tower.

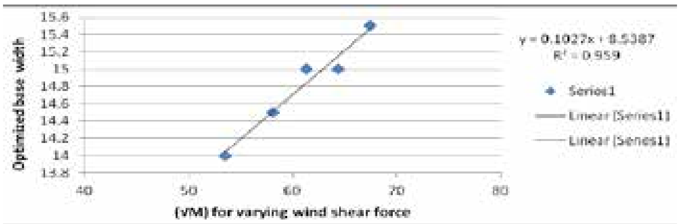


Figure 14: Best fit straight line between base width and √M

From the Table 6 above it is noted that the optimum base width can be obtained for preliminary determination from the following relation:

$$B = 0.24 \sqrt{M}$$

Where B - base width of wind turbine lattice tower in meters

M - overturning moment about the ground level in tonne-meter

Also the following equation has been suggested based on the best fit straight line relationship between the base width and bending moment as shown in Figure 14.

$$B = 0.1027\sqrt{M} + 8.5387$$

9.2. Tubular Tower

Similarly the nine different models with base diameter changing from 3.5 to 5.5m in steps of 0.2m interval were developed and was analyzed for same loading conditions viz.. wind shear force, vertical loads, wind pressure acting along the height, and moment for 73m tubular tower. The total weight of the tower/ steel take off for different base diameters was determined as indicated Table 7.

Table 7: Steel take-off for various base diameters (73m tubular tower)

Models	Base Dia (M)	Weight / steel take off (MT)	Height / base Dia
1	3.5	117.1	20.86
2	3.75	115.9	19.46
3	4	107.8	18.25
4	4.25	107.5	17.17
5	4.5	107.4	16.22
6	4.75	112.9	15.37
7	5	113.5	14.60
8	5.25	114.8	13.90
9	5.5	119.2	13.27

Figure 15 indicates the variation of total weight/steel take off with respect to the base diameter for 73m tall tower. It was concluded that for 73m tall tower the base diameter corresponding to the least weight was 4.5m. A similar analysis was carried out for 30m tubular tower. For both the cases the ratio of the height of the wind turbine to the base diameter works out to about 16 to achieve the least/optimized weight.

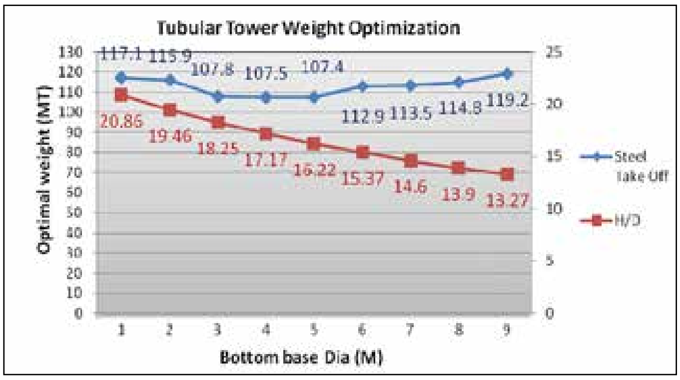


Figure 15: Variation of total weight/steel take-off with respect to the base diameter for 73m tower

9.2.1 Parametric Relation between Base Diameter and Moment for Wind Turbine Tubular Towers

In case of wind turbine tubular towers there is a particular base diameter which gives the minimum total cost of the tubular towers. In order to obtain preliminary determination of base diameter an iterative analysis was further carried out by varying hub level wind shear forces for 73m tubular tower. For the said least weight diameter the bending moment was obtained as detailed in Table 8.

Table 8: Base diameter and moment for varying wind shear force (73m tower)

Sl. No.	Hub level Wind Shear force	Sqrt. of moment at the base of the tower (√M)	Optimized base diameter
	(MT)	(TM)	(M)
1	29	53.65	4.50
2	30	54.66	4.50
3	35	57.96	4.60
4	40	61.12	4.75
5	45	64.00	4.75
6	50	66.97	5.00

Figure 16 indicates the best fit straight line between optimized base diameter and moment at the base for 73m tubular tower.

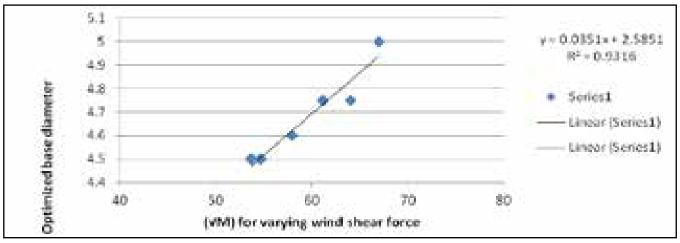


Figure 16: Best fit straight line between base diameter and √M

From the Table 8 above it is noted that the optimum base diameter can be obtained for preliminary determination from the following relation.

$$D = 0.078\ \sqrt{M}$$

Where D - base diameter of wind turbine tubular tower in meters

M - overturning moment about the ground level in tone-meter and also the following equation has been suggested based on the best fit straight line relationship between the base diameter and moment, as shown in Figure 16.

$$D = 0.0351\sqrt{M}+2.5851$$

10. CONCLUSIONS

In the present study, two wind turbine towers viz. lattice and tubular of 73m height were modeled and analyzed using different geometric configurations by changing their base dimensions and keeping the top dimensions as constant. The top dimensions were kept constant due to the constraint that the tip of the blade should not touch the body while passing by the tower. The results indicated that the least/optimum weight of 47.58MT was obtained for the base width of 14m for 73 m high lattice tower. Thus the H/B ratio so obtained was 5.21. Similarly the least/optimal weight of 107.4MT for base diameter of 4.5m for 73m height tubular tower. Thus the H/D ratio obtained was 16.22. Hence, inference drawn from the parametric study is that for selecting the optimized tower the designer/developers shall choose the base width about 1/5th of the height for lattice type towers and the base diameter as


GIGA WOW
Gamesa
Gamesa India cements its No.1* position by adding 1GW in 1 year.
Thank you for making it happen.

1/16th for tubular type towers with which sizeable saving in steel can be achieved, within the limits of static analysis used in the present study. It is inferred that the optimized cost of the lattice tower is about 40 - 45% of the cost corresponding to that of 73m height tubular tower, keeping other parameters as same for the analysis.

Also as an outcome of the study the following parametric relations between the base diameter and bending moment which provides the minimum cost of the wind turbine towers are suggested, based on parametric studies.

a. **Lattice tower:**

B = 0.24 √M - for preliminary determination

B = 0.1027√M + 8.53 - Based on the best fit relationship between base width and M.

b. **Tubular Tower:**

D=0.078 √M - for preliminary determination

D=0.0351√M+2.5851 - Based on the best fit relationship between base diameter and M.

The hub shear for a given wind turbine will generally be provided by the manufacturer. This, multiplied by the hub height gives the moment at the base which is predominant. The moment due to the wind on the tower is negligible. As such the value of 'M' to be used in the formula may be taken as Hub shear x Hub height. Using the above parametric relations the optimized base dimensions can be worked out which will serve as a ready reckoner for a designer to start with for a given height/ hub shear of the tower.

Snippets on Wind Power

ReNew Power Becomes First IPP to Cross 1GW of Renewable Capacity

The five-year-old start-up ReNew Power Ventures Pvt. Ltd, an independent power producer (IPP) and developer of wind and solar energy, has become the first IPP in India to cross an installed capacity of 1 GW (1,000 MW) from clean energy projects in the country. This also makes ReNew Power the largest IPP in the country by way of cumulative installed capacity. The company is slated to bring another 1,400 MW of Renewable power capacity on stream over the next 12 to 18 months.

Indian Renewable Energy Certificate Sales Jump at FY 2015/16 End

Nearly 300,000 solar renewable energy certificates (solar RECs) have been sold in India in January-March 2015, marking an 83% rise in quarter-on-quarter terms, demand remains wide, with 621,200 solar RECs issued for the quarter. For non-solar RECs, on the other hand, this was the first quarter in which buys surpassed certificate issuance in each month. Non-solar REC demand jumped to 2.045 million sold units, which compares to 1.34 million sold in October-December 2015 and to 1.78 million issued for the reporting quarter.

Gamesa grabs 198 MW in India

Gamesa will deliver 50 G114-2.0 MW and 12 G114s turbines in Karnataka and 25 G97-2.0 MW turbines in Rajasthan making a total order of 198 MW.

Wind Energy Capacity Addition Target 4.1 GW in 2016–2017

Wind energy capacity addition target for FY2016–2017 has been set at 4.1 GW, compared to 2.4 GW in FY2015–2016. 2015-16 saw 3400 MW of wind power addition. MNRE also plans to add 12 GW of solar power capacity this year.

Reduction in AD to hit Renewable Energy Sector

Mr. Upendra Tripathy, Secretary, MNRE has said that the renewable energy sector, especially wind energy, is suffering because of the reduction in accelerated depreciation tax benefit as announced in the Budget.

MPERC issues Tariff Order

Madhya Pradesh Electricity Regulatory Commission has issued final wind tariff order and determined tariff of Rs. 4.78/Kwh for the control period of 3 years from 01.4.2016 to 31.3.2019.

TNERC issues Tariff Order

Tamil Nadu Electricity Regulatory Commission (TNERC) has issued a comprehensive tariff order No 3 of 2016 dated 31.03.2016 on wind energy and determined tariff of Rs. 4.16/Kwh effective from 1st April 2016 for the control period of 2 year.

APERC issues Tariff Order

Andhra Pradesh Electricity Regulatory Commission has issued generic preferential tariff of Rs. 4.84/Kwh for without AD Benefit & Rs.4.25/Kwh with AD Benefit for Wind Power Project applicable from 01-04-2016 to 31-03-2017.

Wind in White Sector by MPPCB

Madhya Pradesh Pollution Control Board (MPPCB) issued an order no. 477 dated 6th April 2016 related to exemption of 36 types of white sector industries from the consent to operate (copy attached) and mentioned Wind Power in the Sr. no. 35.

Wind Tower Technologies and Forthcoming Advancements

Mr. Bharathy K, Chief Executive Officer
Windar Renewable Energy Private Limited kbharathy@windar-renovables.com

Evaluation of Wind Turbine Technology

Windmills were used in Persia (present-day Iran) as early as 200 B.C. The wind wheel of Hero of Alexandria marks one of the first known instances of wind powering a machine in history. However, the first known practical windmills were built in Sistan, an Eastern province of Iran, from the 7th century. These "Panemone" were vertical axle windmills, which had long vertical drive shafts with rectangular blades. Made of six to twelve sails covered in reed matting or cloth material, these windmills were used to grind grain or draw up water, and were used in the grist milling and sugarcane industries.

The first electricity-generating wind turbine was a battery charging machine installed in July 1887 by Scottish academic James Blyth to light his holiday home in Marykirk, Scotland. Some months later American inventor Charles F. Brush was able to build the first automatically operated wind turbine after consulting local University professors and colleagues.

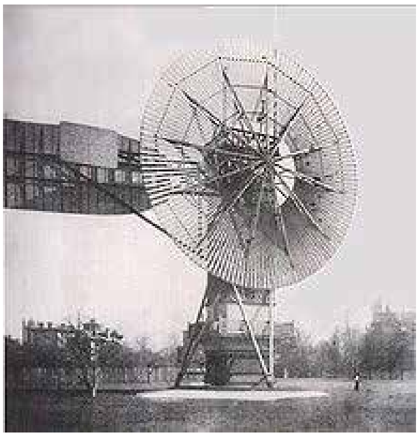


Figure 1: The first automatically operated wind turbine in year 1887. It was 60 feet tall, weighed 4 tons and powered a 12 kW generator.

In Denmark by 1900, there were about 2,500 windmills for mechanical loads such as pumps and mills, producing an estimated combined peak power of about 30 MW ie. 12 KW each. The largest machines were on 79 ft towers.

By 1908 there were 72 wind-driven electric generators operating in the United States from 5 kW to 25 kW. Around the time of World War I, American windmill makers were producing 100,000 farm windmills each year, mostly for water-pumping.

By the 1930s, wind generators for electricity were common on farms, mostly in the United States where distribution systems had not yet been installed. In this period, high-tensile steel was cheap, and the generators were placed atop prefabricated open steel lattice towers.

A forerunner of modern horizontal-axis wind generators was in service at Yalta, USSR in 1931. This was a 100 kW generator on a 98 ft tower.

In the autumn of 1941, the first megawatt-class wind turbine was synchronized to a utility grid in Vermont. The Smith-Putnam wind turbine only ran for 1,100 hours before suffering a critical failure. The unit was not repaired, because of shortage of materials during the war.

Despite these diverse developments, developments in fossil fuel systems almost entirely eliminated any wind turbine systems larger than super micro size. In the early 1970s, however, anti-nuclear protests in Denmark spurred artisan mechanics to develop micro turbines of 22 kW. Organizing owners into associations and co-operatives lead to the lobbying of the government and utilities and provided incentives for larger turbines throughout the 1980s and later. Local activists in Germany, nascent turbine manufacturers in Spain, and large investors in the United States in the early 1990s then lobbied for policies that stimulated the industry in those countries. Later companies formed in India and China.

Present Need for Clean Energy

Now the entire world has realized that building a clean energy future as one of the great challenges of our present time.

In order to address this challenge comprehensive new energy plans are being developed by many countries. Part of this plan calls for 15 percent of our electricity to come from renewable resources, such as wind, solar, geothermal, wave and OTEC by 2015, and 25 percent by 2020.

National Academy of Sciences of the United States, estimated world wind power potential to be 40 times greater than total current power consumption. This large increase over previous studies, which found this multiple to be closer to 7 times, is in large part due to the increasingly common deployment of very large turbines that rise to heights not considered by previous studies.

Evaluation of Wind Tower Technology

As turbines rise to new heights, in order to tap into the greater wind speeds available at these heights, obtaining the most efficient and safe or optimal design of the structures that support them will become of increasing importance to the successful proliferation of wind power.

Over the past 25 years, a significant amount of research has been conducted to formulate the design of various pole and tower structures as optimization problems. This research has provided us with many valuable insights into the optimal design of such structures as well as into the effectiveness of various optimization approaches. Considering the tower and foundation as an integral system, where tower support conditions are not assumed to be perfectly rigid, will allow us to better understand the validity of this technical paper.

Additionally, due to the lack of an official wind turbine tower design standard, previous efforts have relied on a mixture of codes, standards, and engineering judgment to identify design requirements.

A review of the literature surrounding the optimal design of various pole and tower structures is now presented in order to show the current state of the art in the field, review various optimizations approaches, and identify important technical issues connected with each options.

Main Tower Design Considerations

1. Minimization of the tower's mass
2. Maximization of the tower's stiffness
3. Maximization of the tower's stiffness to mass ratio
4. Minimization of vibrations
5. Minimization of a performance index that measures the separation between the structure's natural frequency and the turbine's exciting frequency
6. Maximization of the system natural frequency

In all six design strategies, allowable stress, maximum deflection, resonance, limits on tower mass, limits on mean diameter and limits on wall-thickness constraints were imposed.

Cross-sectional dimension, buckling, tower top deflection and rotation limits are main focus points to be considered. Limits on the towers and combined with foundation system's natural frequency are again an important issue to be design satisfied in order to ensure a satisfactory tower design.

Tower and Foundation Loads

The tower loading consists of loads from the turbine, wind, self-weight, and internal fixtures. Loads from the turbine, which act at the tower top, are obtained from a structural load document provided by the turbine manufacturer. Wind, self-weight, and internal fixture loads are obtained using appropriate formulas. Loads on the foundation, which result from the various loads on the tower, are obtained from the structural load calculations. Additional loading on the foundation includes its self-weight.

Towers can be classified in two major application headings: 1) Onshore wind turbine and 2) Offshore wind turbines. Windar Renewable is specialist in both these types.

Onshore and Offshore Wind Turbines

Onshore wind turbines	Offshore wind turbinesv
Advantages: • It requires cheaper foundations • Easily integrated with the electrical- grid network • Cheaper installation and access during the construction phase. • It can be operated and maintained easily and cheaply	These are two types, namely Near shore and Off shore. **Advantages:** • The roughness of the water surface is very low wind and obstacles to the wind are less. • So, large turbines can be installed • Noise pollution is also not a factor because these are too far from shores
Disadvantages: • Negative visual impact and noise. • Limited availability of lands • Restrictions associated with obstructions like buildings, mountains, etc. • Birds getting trapped in blades • Affected to more turbulence	**Disadvantages:** • Installing offshore wind-turbines is much more complex and costly • Connection to the utility grid is also much more complex and expensive • Operation and maintenance is also a complex task with off shore wind turbines

Figure 2: Onshore Wind Turbines

Figure 3: Offshore Wind Turbines

Parts of a Horizontal Axis Wind Turbine

The basic parts of a horizontal axis wind turbine (HAWT) are foundation, tower, nacelle, generator and rotor blades.

Figure 4: Wind Turbine Parts

Foundation: A very good foundation is required to support the tower and various parts of a wind turbine which weighs in tones say around 180 MT.

Tower

A tower provides support to the nacelle and rotor hub at its top. These are made from tubular steel, concrete, or steel lattice. Height of the tower is an important in design of HWAT. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity. Generally output power of the wind system increase with increase in height and also reduces the turbulence in wind. The theoretical view of tower height versus power out is shown in Figure 5.

Comparison between Low and Tall Towers

Obviously, we get more energy from a larger wind turbine than a small one, but if you take a look at the three wind turbines below, which are 225 kW, 600 kW, and 1,500 kW respectively, and with rotor diameters of 27, 43, and 60 meters, you will notice that the tower heights are different as well.

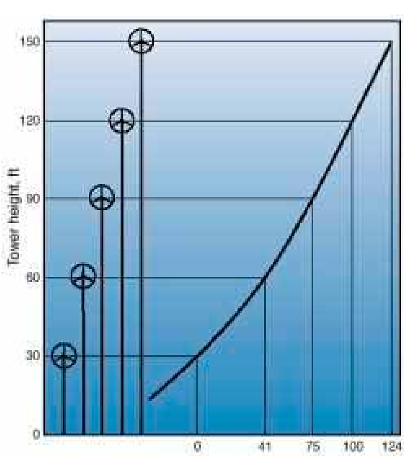
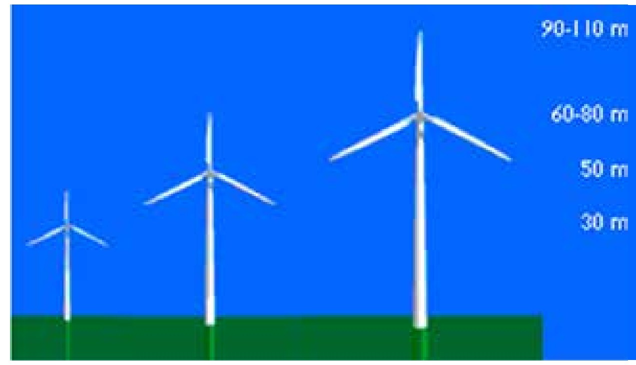


Figure 5: Tower Height vs Power Output

Clearly, we cannot sensibly fit a 60 meter rotor to a tower of less than 30 meters. But if we consider the cost of a large rotor



and a large generator and gearbox, it would surely be a waste to put it on a small tower, because we get much higher wind speeds and thus more energy with a tall tower.

Each meter of tower height costs money so the **optimum height** of the tower is a function of:

1. tower costs per meter (10 meter extra tower will presently cost about Rs. 20 lacs)
2. how much the wind locally varies with the height above ground level, i.e. the average local terrain roughness (large roughness makes it more useful with a taller tower),
3. the price the turbine owner gets for an additional kilowatt hour of electricity.

Manufacturers often deliver machines where the tower height is equal to the rotor diameter. Aesthetically, many people find that turbines are more pleasant to look at, if the tower height is roughly equal to the rotor diameter.

Different Types of Wind Turbine Towers	Structure
 *Figure 6: Tubular Tower*	
Tubular Tower: They are constructed from rolled steel plates welded together with flanges on top and bottom, being sprayed with several coats of gray weatherproof paint. They have doors top and bottom allowing entrance to the vertical ladders inside used to access the power cables and the yaw mechanism. There may also be a set of vertical ladders on the outside of the tower accessing the nacelle for maintenance and other checks. 85% of nacelles operate in this type of tower.	

Different Types of Wind Turbine Towers	Structure
Lattice tower: A lattice tower can be constructed using L angles. They have disadvantages and advantages for wind energy	 *Figure 7: Lattice tower*
Guyed wind tower: These are very strong and most economical when properly installed. But it requires more space around the tower for guy wires	 *Figure 8: Guy Tower*
Tilt up Wind Towers: These types of towers are used for consumer wind energy and for lower power generating wind machines.	 *Figure 9: Tilt up Tower*
Free Standing Tower: These can be used for small wind turbines with cautions.	 *Figure 10: Free stand tower*

Hybrid Tower Solutions

Some towers are made in different combinations of the techniques mentioned above. One example is the three-legged 95 kW tower between a lattice tower and a guyed tower. Similar concept can be adopted combining lattice and tubular tower also.

Forthcoming Technical Advancement in Tower Designs

To cope up with increasing MW class machines and practical constrain in tower transportation, designers are already in advanced stage to commercialize telescopic towers, flangeless towers, vertically split towers, etc.

Tower Production Process

Tower production process is divided into three major stages i.e. shell fabrication, section fabrication in black & section finish in white.

Shell Fabrication:

– The process starts with the receipt of materials like raw steel plates, flanges, weldable internals, paints & screwable internals etc.

– After receipt, the material is duly inspected and approved by the quality team and identification of items is done at this stage.

– Once the material is identified, all raw steel plates are cut as per the layout in CNC plasma /oxy fuel cutting machine and stacked in sequence of tower sections.

– The cut steel plates are shaped into shell through rolling machine. These rolled shells have long seam welded by SAW welding process.

Section Fabrication in Black:

– The tubular section is made of various shells fitted with the flanges at both the end. Therefore the first step is to fit a flange to a shell and add more shell up to maximum, and finish a section by fitting up flange to the last shell.

– Once the shells are converted into section, it is followed by external SAW welding and internal SAW welding. Section Weldable internals like ladders, platform, etc. are fixed & welded to the section.

– The complete section welds are then inspected and cleared by NDT tests and also all dimensional are checked before clearing section from black stge.

Section Finish in White:

– The final black section is sent to blasting booth for surface preparation by shot/grit blasting followed by cleaning from both sides.

– After blasting of section, it is painted & dried up in painting booth. All screwable internals like ladder, platforms etc. are then fitted to painted section.

– A finished white section is duly inspected by quality team and is released for despatch.

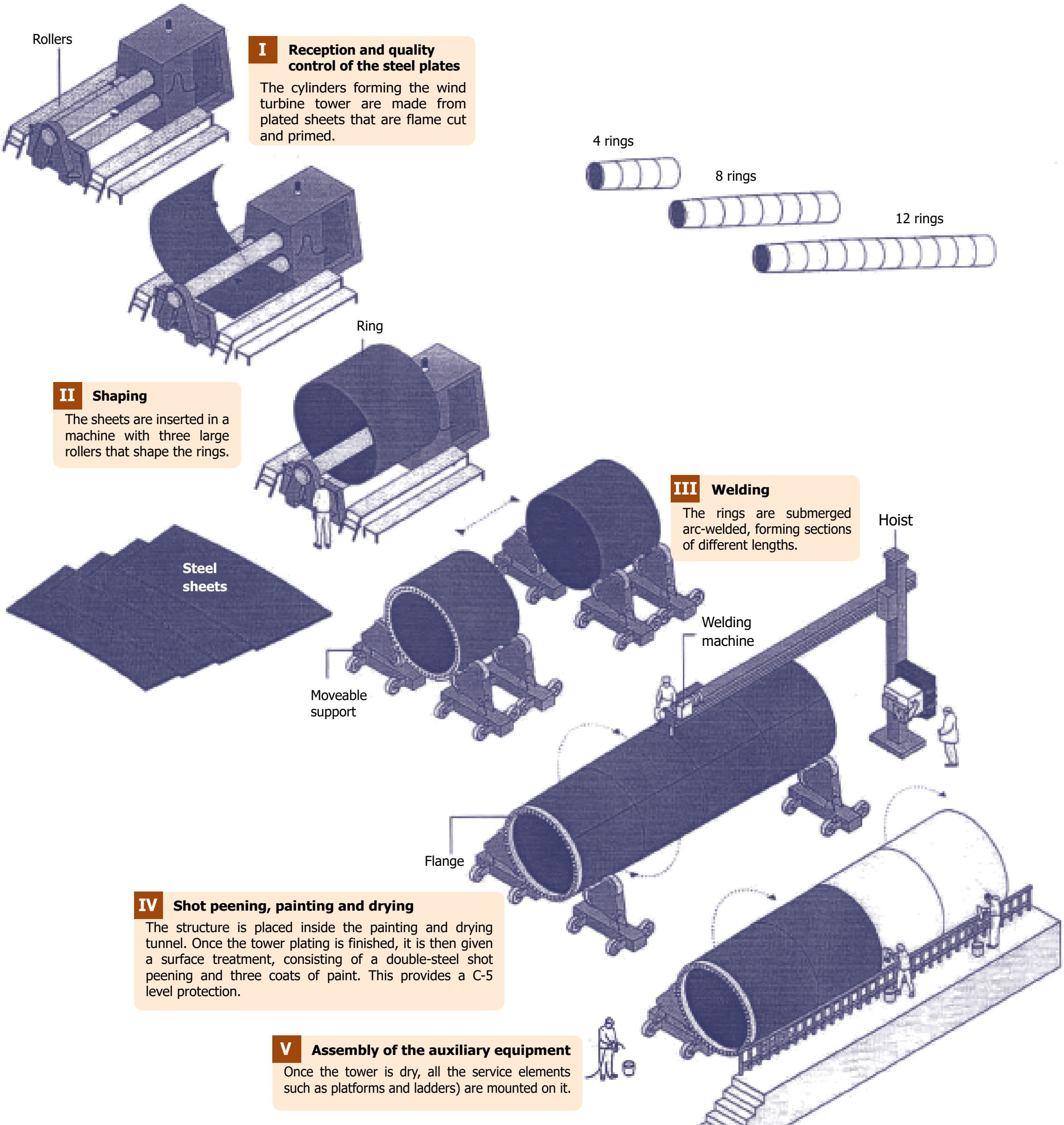
Windar India Halol Plant for Tower Manufacturing

The tower manufacturing factory needs very large areas for raw material, workshop for manufacturing process and storage, which provides added value in terms of logistics. Gantry Cranes are also needed in the storage yard to handle and pick any tower sections at any time or seasons.

A Tower Section Manufacturing in Process

Some companies are also exporting the towers to other countries. Now most of the turbines installed in India are in between the range of 1.5 to 2.5 MW. Hence the height of the tower is regularly on increase from 30 meters to 80, 100 meters and beyond. Hence maintaining high quality is must.

Certifications like LRQA for the Quality Management System ISO 9001, the Environmental System ISO 14001 & the Occupational Health & Safety Management System ISO 18001, TUV Nord Systems GmbH & Co. KG for the welding workshop in the product range of Steel Tower for Wind Turbines of the Standard



Tower Production Process


20 YEARS
OF REVOLUTIONIZING WIND ENERGY IN INDIA
Suzlon's contribution in building India's wind energy sector has been inspired by its ideology of 'powering a greener tomorrow'. With our reach and capabilities, we are best equipped to capitalize the new opportunities that promise to take India and us to newer heights.
Suzlon in India
• World-class technology, manufacturing and services
• More than 1700 customers
• Installed base of more than 8500 MW
• Lighting-up more than 20 million lives
20 years of revolutionizing wind energy
SUZLON
POWERING A GREENER TOMORROW
www.suzlon.com
Follow us on:

DIN EN ISO 3834-2 (EN 729-2) are also part of providing the quality product.

There are several challenges for tower manufacturers in terms of raw material supply and finished goods dispatches but the industry is poised for significant growth in the coming years.

Having the strong financial and technical expertise of the parent company - in manufacturing metal structures and knowledge hub for renewable energy technologies, high indexes in the quality of the finishing of works and opportunities offered by the Indian wind power segment, Windar India will be offering global solutions to its clients and is set to emerge as the largest wind tower manufacturer in India.

CERC Declares Generic Tariff:

CERC has declared generic tariff for RE Technologies for FY 2016-17 vide its order Date of Order: 29th April 2016. Generic Tariff for Wind Energy for FY 2016-2017 is tabulated below.

Particulars	Levellised Total Tariff, (Rs/kwh)	Benefit of Accelerated Depreciation (If availed), (Rs/kwh)	Net levellised Tariff (upon adjusting for AD benefit) (If availed), (Rs/kwh)
Wind Zone-1 (CUF 20%)	6.60	0.71	5.89
Wind Zone-2 (CUF 22%)	6.00	0.65	5.36
Wind Zone-3 (CUF 25%)	5.28	0.57	4.71
Wind Zone-4 (CUF 30%)	4.40	0.47	3.93
Wind Zone-5 (CUF 32%)	4.13	0.44	3.68

MERC issues Renewable Energy Purchase Obligation

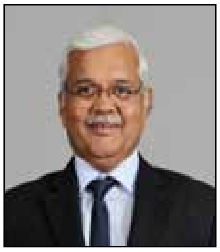
Maharashtra Electricity Regulatory Commission (MERC) has issued the "Renewable Energy Purchase Obligation, its Compliance and Implementation of Renewable Energy Certificate Framework, Regulation, 2016" for the operating period from 1st April 2016 to 31st March 2020. The regulation will be applicable on Distribution Licensees, Captive Users and Open Access consumers as per their respective regulations (with various conditions) and RPO targets are:

YEAR	Quantum of purchase from Renewable Energy sources (in %)		
	SOLAR	NON-SOLAR (other RE)	TOTAL
2016-2017	1.00%	10.00%	11.00%
2017-2018	2.00%	10.50%	12.50%
2018-2019	2.75%	11.00%	13.75%
2019-2020	3.50%	11.50%	15.00%

Rs. 4,000 - crore Investments in Wind Energy on Brink of Becoming NPAs

Maharashtra State Electricity Distribution Co Ltd (MSEDCL) has refused to sign power purchase agreements (PPA) or issue commissioning certificates to 364.15 MW of wind projects that were ready in 2014-15 and another 192.05 MW were completed in 2015-16. Hence the investment of Rs 4,000 crore in wind energy projects is on the verge of becoming non-performing assets.

Wind Turbine Generators: The Evolution of Tower Technology



Vinod R Tanti, Chief Operating Officer (COO), Suzlon Group

One of the most important components of a wind turbine is its tower.

Often the importance of the role that the tower plays in the design of a wind turbine goes unnoticed. Most people assume its primary function to be carrying the nacelle and rotor to which the blades are attached. However, the tower is responsible for many more functions, one of which is to raise the turbine above surrounding obstacles and to a height where clean and unobstructed wind becomes available and harvest the maximum wind energy by accommodating the suitable size rotor dia. Furthermore, the tower needs to absorb the large static and dynamic loads brought about by the power of varying wind.

Given its role in the smooth operation of a turbine and in effective energy generation, the tower has undergone a large amount of innovation in design and construction over decades. This has resulted in numerous types of towers, each catering to set of conditions and circumstances. The height of the turbine, the wind conditions and the type of land – flat ground, mountainous terrain, thick covering of tall trees or rocky and uneven ground – are all important aspects of the tower design. Each of these factors plays a role in determining the most effective tower structure that will provide the desired result of stability, height and load bearing capacity.

Up until 15 years ago, lattice towers were the norm for wind turbines. Manufactured with welded steel profiles, they offered the advantages of a sturdy base that could better absorb the buffeting of winds with reduced wear and tear. Furthermore, when compared to the more recent tubular towers, they required less steel, thereby offering a large cost advantage. However, when height became a consideration to overcome the problem of low wind, lattice towers fell short.

Many regions were left untapped because their wind resources were not strong enough at the prevailing wind turbine heights for adequate generation. Capitalising on cleaner and stronger winds required an increase in hub height. The solution was to develop taller turbines. The science behind this is quite simple. A wind turbine's power output is a function of the cube of the wind velocity and density. As a result, a small increase in wind speed, as felt by a taller tower, will have a large impact on energy generation. The height of the tower is thus dependent on the cost of manufacturing such a tall tower versus the increase in value brought on by increased generation.

Another advantage of a taller tower is to tap air that is less turbulent resulting from absence of obstructions such as trees and buildings. Towers under 100 metres in height can face greater wear and tear due to higher wind turbulence as a result of a higher number of obstructions. Taller turbines overcome this drawback as they face less turbulent winds, increasing their life. Hence, the fact that taller towers were the next step in tower technology evolution was a given. The question then became one of how, because lattice towers could not accommodate such heights. In fact, lattice towers were optimum until the height of 60 metres. Consequently, when the time came for towers that were over 60 metres in height, wind turbine manufacturers made the move from lattice to tubular towers.

Tubular towers are built in individual sections of 20 metres to 30 metres each and flanges at either end. With a tower that has a thick base and narrower top, the tower is made logistic-friendly by being bolted together only once on-site. The conical shape allows for greater cost efficiency than a straight tower and greater stability through a wider base. However, the tubular tower too has a height limitation. When applied to turbines of over 100 metres, the design needs to incorporate a thicker base. This adversely impacts the cost. Furthermore, this design becomes unfeasible for transport, resulting in applicability to only those sites that are accessible through unobstructed roads or vessels and availability of required size steel plates and manufacturing infrastructure. Some players in the industry have achieved success on the design, transport and installation of such tubular towers that go up to 120 metres.

Suzlon, however, took a different path. With the innovation of a hybrid tower, it presented itself as a solution in going higher than conventional towers.

The hybrid tower is a combination of a lattice tower and a tubular tower. A tubular tower is attached to a lattice base with a unique transition piece. Placed on top of a lattice base, the transition piece acts as a elevated foundation for the tubular sections of tower, allowing the transition from one type of tower to the other to be stable, safe and effective. Although completely constructed using steel, the hybrid tower offers the advantage of reduced material usage and therefore less weight.

The lattice base uses 33% less concrete in its foundation than a tubular tower of the same height would, resulting in reduced cost of foundation.

In fact, the hybrid tower is evidence of weight optimization in tower design. A reduced mass per kW of energy, through reduced steel usage, translates into increased natural resource saving and greater environment-friendliness. Testament to this is the fact that at a height of 120 metres, a tubular tower would weigh much higher, as compared to a hybrid tower.

Furthermore, its wide stance, achieved through the lattice tower base as opposed to a tubular one, offers enhanced stability, cohesive to achieving greater height. This allows the wind turbine generators to scale new heights where wind speeds and consequent generation are greater. As a result, sites that remained previously unviable become viable, overcoming the limitations of windy site scarcity.

Logistics play a very important role for the advantage of cost, time and other related risks. Hybrid towers overcome numerous potential problems and offer increased accessibility as they are also constructed on site. This makes them more logistic-friendly and consequently, cost effective. It also provides local employment.

Hybrid towers are increasingly becoming the norm as the industry moves towards higher hub heights. Suzlon too has embraced this step and introduced the S97 and S111, the latest innovations from our 2.1 MW platform of products. The S97 120m turbine is, in fact, the highest all-steel tower wind turbine in the world at a height of 120 metres. Keeping with the national movement to increase investment in, and use of, renewable energy, Suzlon's hybrid towers have been designed to lower the Levelized Cost of Energy (LCoE) and offer a safe and secure investment with excellent, long term Return on Investment (ROI). These hybrid towers combine a lattice base with a tubular tower, brought together with a unique transition piece. As a result, we have been able to scale a height of 120 metres and open up those sites that were previously unusable due to low wind resource. The evidence of design success lies in the fact that the prototype of the S97 120m hybrid tower, commissioned in Gujarat in June 2014, has achieved a 35% Plant Load Factor (PLF) which is higher than the industry average of 25% to 30%.

But there is more than meeting the need for height, reduced weight, reduced cost and greater stability that goes into designing a hybrid tower. Tower technology, in practice, is heavily reliant on quality control. A flawless design can be rendered ineffective if not supported by quality control and stringent parameters that are analysed for optimum versus actual.

Wind turbine manufacturers need to ensure that their towers can accommodate heavy static and dynamic loads. Tolerances, which can be allowable as deviations from the set design parameters, need to be kept at a minimum. This can be achieved through quality checks at every stage of manufacture and installation.

Another point of consideration during the manufacture of towers and tower components is production time. The difference in production cycle time can affect customer decision when selecting a renewable energy partner. How successful a plant is, and how optimized its production cycle time is, depends on its setup. Suzlon, for instance, uses a linear production setup that places heavy focus on manpower. It gives us a 16 day production cycle, which is at par with industry standards.

To conclude, it can be stated that the tower is the foundation on which a turbine is installed. The time now is for taller turbines that enable larger rotors/diameters. History proves that necessity is the mother of invention – lattice towers gave way to tubular towers, and now we are moving towards the technology of hybrid towers. Yet, regardless of the type of tower, what remains consistent is the advantage of cost, weight, logistics, and production time. One these aspects, tower technology across the industry remains common; and the aim is to bring about the best in each aspect while also maintaining quality and minimising deviations from design.

Advertisements

National Institute of Wind Energy	–	2nd Wrapper
Windergy India 2017	–	3rd Wrapper
Regen Powertech Private Limited	–	4th Wrapper
RRB Energy Limited	–	5
SKF	–	11
Bonfiglioli Transmissions (Pvt.) Ltd.	–	17
Gamesa Renewable Pvt. Limited	–	20-21
LM Wind Power	–	25
Suzlon	–	29
NGC Transmission Asia Pacific Pvt Ltd.	–	35

Theme of the Next Issue

The theme of the next issue of Indian Wind Power is "Gearbox Technology".

We invite relevant articles to the theme. We solicit your cooperation.

Editor

Structural Analysis, Design and Field Testing of Wind Turbine Support Towers




P. Harikrishna
Sr. Principal Scientist

A. Abraham
Sr. Scientist

S. Selvi Rajan
Chief Scientist

G. Ramesh Babu
Principal Scientist

Wind Engineering Laboratory, CSIR-Structural Engineering Research Centre, Chennai

Introduction

Wind power in India has an estimated potential of 302 GW of electricity generation capacity at 100m height (ref. www.niwe.res.in) under the renewable energy sources sector. The Indian wind energy sector has an installed capacity of 26769 MW (as on March 31, 2016, ref. MNRE) and is ranked 4th in the world. The wind energy is converted into electrical energy using Wind Turbines, which are supported on elevated towers. The cost of wind turbine tower and its foundation is generally about one tenth of the capital investment of a wind turbine system. However, the satisfactory functioning of the wind turbine during its intended life time requires the safe design of the support tower against survival wind loads and turbine operating fatigue loads.

The CSIR-SERC has State-of-the-art facilities and expertise for carrying out studies on structural analysis, design and testing of wind turbine support towers and blades using Mobile Laboratory equipped with DAQ system for field instrumentation on prototype structures and Boundary Layer Wind Tunnel (BLWT) for model testing. In the last couple of decades, CSIR-SERC has efficiently utilized these facilities and expertise in serving various industries related to wind energy sector.

Structural Analysis and Design of Wind Turbine Support Lattice Towers

The Centre has carried out analysis of towers (with heights varying between 35 m and 50 m) supporting wind turbines with capacities ranging from 80 kW to 500 kW. Design criteria for these towers involve safety against survival wind loads and also against fatigue damage due to cyclic operating loads during its intended life time (usually 20 years). For the safe design of wind turbine support tower, the tower needs to be designed for 6-component tower top loads (FX, FY, FZ, MX, MY and MZ) under survival wind speed (with the turbine under stalled condition) in addition to the wind loads on the support tower (Figure 1). Further, the towers need to be designed for fatigue damage caused by 6-component tower top load ranges with specified number of cycles during its life time under different operating wind speeds. Modal analysis of the tower with tower top mass is carried out to obtain various natural frequencies of the tower and their mode shapes (Figure 2). The dynamic sensitivity of the tower to wind turbulence, rotor rpm and its harmonics, and natural frequencies of blade is assessed for the evaluation of dynamic amplification factors, if any. Under survival wind speed, the tower is analysed for the 6-component tower top loads (which are turbine specific) due to wind induced loads on the nacelle and blades along with wind loads on the tower.

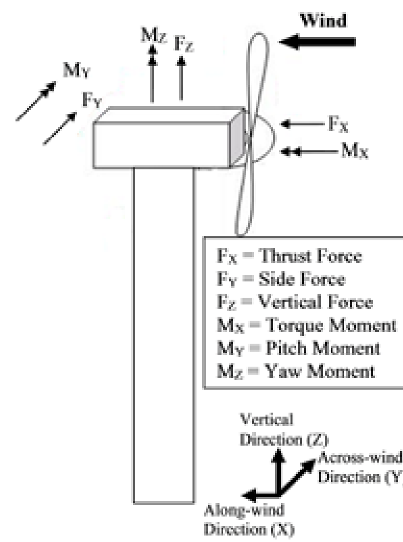
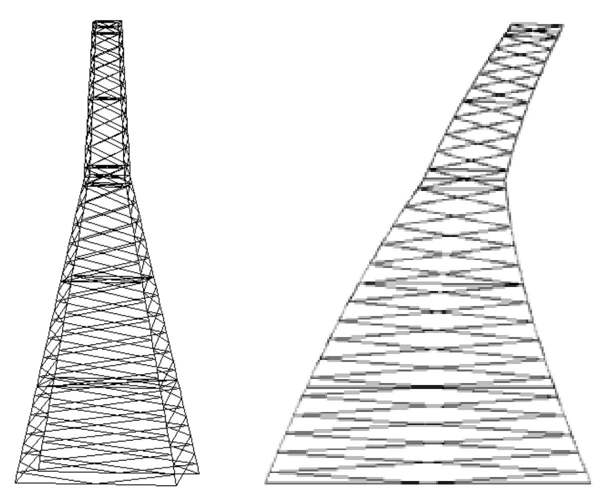


Figure 1: Schematic diagram of 6-component tower top loads



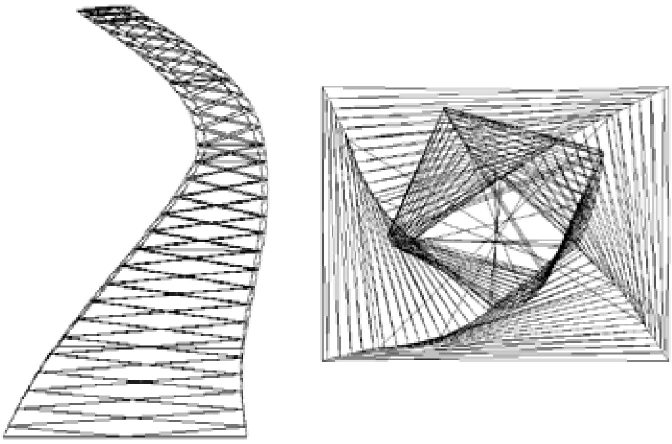


Figure 2: Finite element modeling of a tall tower supporting a wind turbine and its mode shapes

Under operating wind speed range (i.e. between cut-in and cut-out/cut-off wind speeds), the tower will be subjected to 6-component tower top turbine operating loads, which are turbine specific, with specific amplitude ranges. These operating load ranges cause different levels of fatigue damage to the tower members/sections in various operating wind speed bins. Based on Miner's rule, the fatigue damage in each wind speed bin is obtained as a ratio of the number of operating cycles (based on the site specific annual wind speed distribution) to the total number of cycles for failure (based on structural analysis using operating load ranges and material/detail specific S-N curve). The cumulative fatigue damage of the tower over its life-time is obtained as a sum of the evaluated fatigue damages in each wind speed bin. Design recommendations are given based on the analysis of the tower for survival wind loads and for operating load ranges in various operating wind speed bins.

Structural Analysis, Design and Field Testing of Wind Turbine Support Guyed Tubular Tilt-up Tower

As part of New Millennium Indian Technology Leadership Initiative (NMITLI) project on "Development of a 500 kW low-cost horizontal-axis wind turbine", CSIR-SERC, in collaboration with CSIR-NAL, Bengaluru, has carried out structural analysis and design of a 60 m tall guyed tubular tilt-up tower supporting a 500 kW down-wind type wind turbine with 2-blades. The tower has been supported by four guys at the 42 m level and anchored at the ground level at a diagonal spacing of 25 m from the tower base. Finite element analysis of the tower has been carried out for various inclined positions of the tower to take into account the tilt-up action. The tubular sections have been designed with slip-joints with specified segment lengths along the height of the tower. Further, the prototype wind turbine support tower has been field tested by CSIR-SERC to assess its dynamic structural characteristics (Figure 3).

Figure 3: Field testing of 60 m tall guyed tower supporting 500 kW capacity down-wind type wind turbine

Field Investigations of Wind Turbine Support Towers

Wind turbine support towers are generally designed for 6-component tower top loads specific to the wind turbine characteristics and based on standard reference terrain/ turbulence conditions. However, these standard reference terrain/turbulence characteristics can not be comparable to all wind farm sites, which are specific to local topographical features. Further, these towers are designed for standard operating load conditions. However, frequent occurrence of various other operating load conditions, viz. Grid failure causing sudden brake to the operation and followed by restarting the turbine, can cause significant fatigue damage during the life time of the tower due to high amplitude fatigue cycles. These issues warrant full-scale field testing of the wind turbine support towers for various operating load conditions under site-specific terrain/turbulence conditions. Due to very high capital investments and continuous maintenance of state-of-art instrumentation facilities, there are only a few prototype testing stations, exclusively for wind turbines. Nevertheless, lower capital costs and experienced manpower, measurements over a period of couple of weeks during seasonal wind conditions, could be used to get reliable data from the specific site for the evaluation of fatigue damage (per hour) in critical members under different operating wind speed bins and under various miscellaneous operating wind conditions. These data can be used to verify the fatigue damage evaluated at the design stage and for the evaluation of fatigue life of the tower.

Geared for a Better Future

2.5MW NGC Wind Gearbox

Visit us at booth #1.149

Renewable Energy India Expo
A UBM Event
23-25 SEPTEMBER, 2015
India Expo Centre, Greater Noida, India

Advanced Wind Gearbox and Transmission System Solutions

NGC is a global leader in wind gearbox development and production of high performance main gearboxes, yaw and pitch drive product for the wind turbine industry. NGC's high reliability products are adapted to various onshore and offshore working conditions, including Class I to III sites, extended temperature conditions and high altitude environment. To date, more than 37,000 NGC gearboxes have been in operation all over the world, contributing to a cleaner and more responsible power generation for a sustainable future.

For enquiry, please contact:
NGC Transmission Asia Pacific Pte Ltd
51, Changi Business Park Central 2, #06-08, The Signature, Singapore 486066
Tel: +65 6589 8588 Fax: +65 6588 3557
Email: APRegion@NGCtransmission.com

NGC

www.NGCtransmission.com

Centre has developed expertise and carried out field testing of many lattice towers supporting up-wind/down-wind type wind turbines with capacities ranging from 225 kW to 1 MW and with 2/3-blades in various wind farm sites (Figure 4).

Figure 4: Field testing of different lattice towers supporting wind turbines

Typical instrumentation of a tower includes anemometers at reference height for measuring wind speed and direction, tri-axial accelerometer at the top of the tower for measuring the vibrations of tower and strain gauges at critical elevations of the tower for measuring the member stresses (Figure 5).

Figure 5: View of propeller anemometer, strain gauge instrumentation and tri-axial accelerometer

The measurements are carried out over a period of 1 or 2 weeks using DAQ systems containing built-in strain gauge signal conditioners housed in a Mobile Laboratory (Figure 6).

Figure 6: Views of mobile laboratory and DAQ system inside mobile laboratory

The data are collected under turbine stalled condition, turbine operating conditions in various wind speed bins and under various other operating conditions (Figure 7). The measured data is analysed for the evaluation of natural frequencies of the tower and blade, and various operating frequencies, viz. rotor rpm and its harmonics (Figure 8).

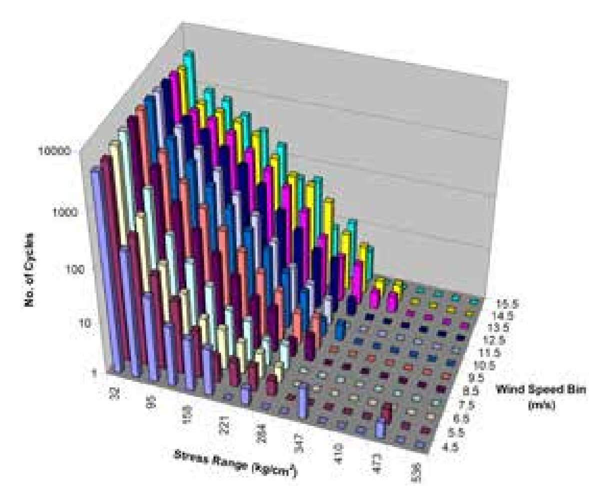


Figure 7: Typical measured tower base strain during different operating Conditions

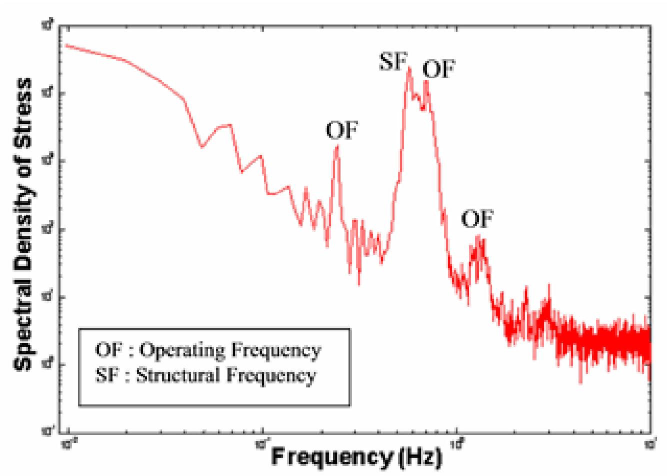


Figure 8: Typical evaluated stress spectrum with peaks at operating and structural frequencies

Further, the evaluated stress time histories are analysed using Rainflow Counting Technique to evaluate number of fatigue cycles in different stress amplitude ranges and to evaluate per hour fatigue damage (Figure 9).

Based on the measured data covering different operating wind speed bins, recommendations are provided for strengthening the tower for critical members/section based on cumulative fatigue damage is evaluated over the life time of the tower.

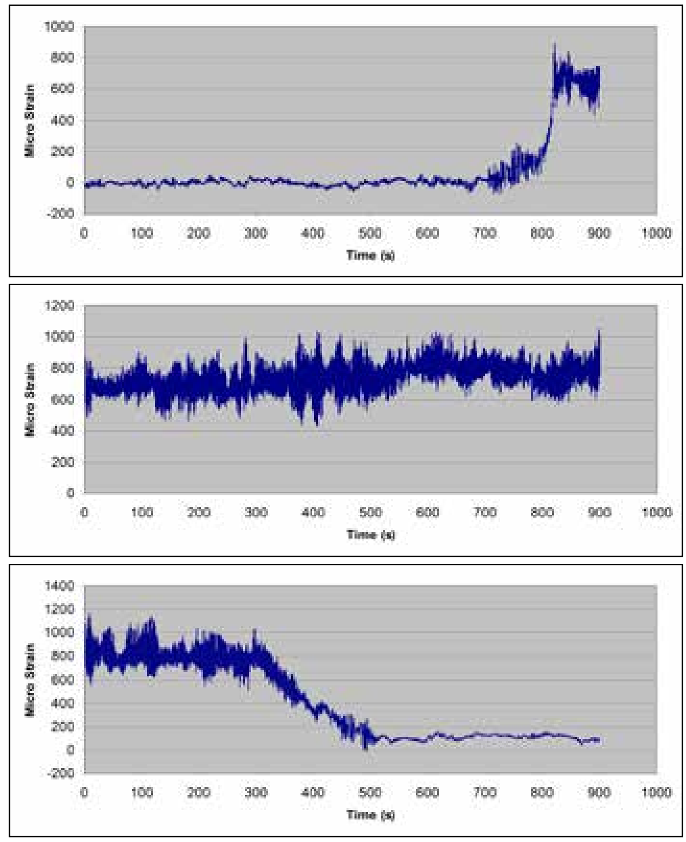


Figure 9: Distribution of Rainflow counted cycles for different stress ranges in various wind speed bins

Wind Industry News

- Inox Wind Limited has bagged an order for a 20 MW wind power project (10 units of 2MW DFIG 93.3 rotor diameter WTGs) to be set up at Nipaniya, Mandsaur in the state of Madhya Pradesh from PTC Energy Limited (PEL).
- According to IT, Urban Development and Municipal Administration Minister of Telangana Mr. K T Rama Rao, the Suzlon Group is charting out a Rs 1,200 -crore investment plan to take up 3000 MW solar, wind and hybrid power project in the state of Telangana.
- Suzlon has secured work on several wind projects with a combined capacity of 81.9 MW, 90% from the old customers from Tamil Nadu, Gujarat, Andhra Pradesh and Madhya Pradesh. Over 75% of the order are for its newly launched S97 120m hybrid tower and S111 90m machines.
- Suzlon has won a 105 - MW turbine order from Greenko Group for 50 S97 2.1 - MW wind turbine generator with hybrid tower to be installed at a wind park in Andhra Pradesh.
- Inox Wind has won two contracts for turbines totalling 70MW from Adani Green Energy for 50 MW wind farm in Anantapur district of Andhra Pradesh and a 20MW plant at Inox Wind's Lahori site in Madhya Pradesh.
- Denmark-based LM Wind Power has inaugurated its second manufacturing wind turbine blade facility at Halol near Vadodara in Gujarat with an investment of 25 million euros or Rs 200 crore.
- Inox Wind has bagged two orders for a cumulative capacity of 100 MW from one of India's leading renewable energy independent power producers. The turnkey orders comprise of a 50 MW project to be set up in Gujarat and a 50 MW project to be set up in Madhya Pradesh.
- Gamesa has bagged a 40MW order from developer ReNew Power for a wind farm in the Karnataka to install 20 G97-2.0MW class S machines with tower heights of 104 metres.
- Suzlon Energy Ltd has aquired Gale Solarfarms Private Limited, Tornado Solarfarms Private Limited, Abha Solarfarms Private Limited, Aalok Solarfarms Private Limited and Shreyas Solarfarms Private Limited increase its presence in India's renewable energy sector.

Snippets on Wind Power

Renewable Projects: India may seek Funds for Hedging Currency Risks

Mr. Ajay Mathur, a member of the Prime Minister's Council on Climate Change, and former Director General of the Bureau of Energy Efficiency has told that the foreign funding for the projects could be had at 2-3 per cent. However, financing cost for currency hedge for three-five years for a project developer is at around 7 per cent. This makes renewable energy project costly and unviable for supplying power at a competitive rate. To reduce the finance cost and mitigation of currency fluctuation risk hedge for solar and wind energy projects, the Centre is considering a channel of funds from Global Climate Fund (GCF). The special funding could be as low-cost grants from GCF, hence the Centre is considering seeking special long-term fund (10 years and above), which costs around 2-3 per cent. The Union Government is also considering a hedging instrument that takes care of the needs of the renewable energy sector. Meanwhile, SIDBI and IDFC have applied for accreditation from GCF for project evaluation and due diligence. South Korea-headquartered GCF has already accredited NABARD for such work for Indian renewable projects.

IREDA Scheme for discounting of Energy Bills

IREDA has issued a scheme for discounting of Energy Bills for the purpose of credit under the bill discounting to all IREDA Borrowers who are selling Energy to State Discoms/ SECI/NVVN etc. RE generators are exporting energy to State Discoms/SECI/NVVN etc. and raise energy bill against the unit exported on monthly basis. Many of them RE generators are not getting payment within stipulated time period and the same is impacting the debt servicing obligation of the borrowers. In view of that IREDA proposed to provide bill discounting facility for the energy bills of IREDA borrowers which are pending for payment with utilities for up to 6 months.

ICRA says - MP and Maharashtra may Trip Wind Energy Capacity Additions

In Madhya Pradesh, wind energy tariff has been revised downwards from Rs 5.96 per unit to Rs 4.78 per unit, while the same in Tamil Nadu (TN) has been revised upwards from Rs 3.51 per unit to Rs 4.16 per unit. Madhya Pradesh has topped the wind energy addition in FY 2015-16 in one year by any state so far. ICRA in its latest research on wind energy sector has expressed that reduction in preferential tariff by State Electricity Regulatory Commission (SERC) is a negative development for new wind energy projects to be commissioned in Madhya Pradesh. This reduction in tariff in MP, coupled with slowdown in signing of fresh power purchase agreements (PPAs) over last 6-8 month period & reported delays in payments by state owned utility in the state of Maharashtra as per industry sources is further likely to impact fresh wind energy capacity addition expected in the country in near to medium term to some extent.

CERC (DSM and related matters) Regulations Amendment

CERC has issued CERC (Deviation Settlement Mechanism and related matters) (Third Amendment) Regulations, 2016 dated 6th May 2016. The major findings of the amended Regulations are:

- Deviation shall be calculated for the Regional Entities by concerned RLDC/RPC which shall be attributed to various entities embedded within State by SLDC.
- Renewable Rich State means a State whose minimum combined installed capacity of wind and solar power is 1000 MW or more.
- Deviation for under-drawls/over-injection by a renewable rich state in a time block in excess of limits as specified below:

Sr. No.	States having combined installed capacity of Wind and Solar projects	Deviation Limits (MW)- "L"
1.	1000 – 3000 MW	200
2.	> 3000 MW	250

- Applicable Charges for Deviation shall be applicable for over-drawal as well as under-injection of electricity for renewable rich states:

(i)	For over-drawal/ under-injection of electricity above L MW and up to L+50 MW in a time block	Equivalent to 20% of the Charge for Deviation corresponding to average grid frequency of the time block
(ii)	For over-drawal / under-injection of electricity above L+50 MW and up to L+100 MW in a time block	Equivalent to 40% of the Charge for Deviation corresponding to average grid frequency of the time block
(iii)	For over-drawal / under-injection of electricity above L+100 MW in a time block	Equivalent to 100% of the Charge for Deviation corresponding to average grid frequency of the time block.

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

Photo Feature

Regional Interactive Workshop on Wind Energy at Ahmedabad 19th April 2016

IWTMA and CII-Sohrabji Godrej Green Business Centre organized an Interactive Workshop on Wind Energy at Ahmedabad on 19th April 2016. Photograph taken during the workshop:

Left to Right: Mr. S. Raghupathy, Executive Director, CII-Godrej GBC; Mr. Ramesh Kymal, Chairman, RE Council, CII-Godrej GBC & Chairman and Managing Director, Gamesa Renewable Ltd.; Mr. Ishwarbhai M. Bhavsar, Chairman, Gujarat Energy Development Agency; Smt. Shobhana Desai, Additional Secretary to Govt, Energy Dept, Government of Gujarat and Mr. Sarvesh Kumar, Chairman, IWTMA and Deputy Managing Director, RRB Energy Limited.

A view of the delegates at the workshop

IWTMA Meeting with SAIL on April 04, 2016

A view of the SAIL meeting

After introduction of Minimum Import Price and initiation of proceedings of Safe Guard Duty (SGD) on Steel Plates, IWTMA felt the need to get involved with the subject in the interest of our members. IWTMA has taken part in the hearing of SGD and have submitted our version. IWTMA also took up the matter with Ministry of Commerce, Ministry of Steel and SAIL and decided to make joint efforts to create a favourable situation for the wind industry. Consequently SAIL & IWTMA jointly organised a meeting on Monday, 4th April 2016 at Chennai. SAIL officials of Quality, Application Engineering, Production and Marketing joined from Bhilai, Rourkela, Kolkata and Chennai participated for discussing the supply of Steel Plates for the manufacture of Tower.

IWTMA was represented by its Associate Director and Commercial & Technical heads of the members like Gamesa, Regen, Inox, Vestas, RRB Energy and Leitwind Sriram. SAIL presentations on the newly acquired capabilities by Rourkela & facilities available at Bhillai plant and a case study with Gamesa were made.

IWTMA made a presentation on behalf of industry.

Know Your Member

ReGen Powertech Private Limited

ReGen was established in 2006 to manufacture Direct Drive (gearless) wind turbines with PMG technology in partnership with Vensys AG, Germany for 1.5 MW, 2.0 MW, 2.5 MW and 3.0 MW wind turbines. Wind Direct – ReGen's R & D Division based in Germany has developed 2.8 MW WEC for the international market. ReGen is the third largest player in Indian market with an installed capacity of 2000 MW.

ReGen has fully integrated, state-of-the-art production facility near Tada in Andhra Pradesh, and Udaipur in Rajasthan, India. The plant houses a sophisticated manufacturing line for 1000 MW and a world-class R&D Center. It has upgraded technology for 1.5 MW platform to maximize efficiency of V77, V82 and V87 models. It will soon be launching V115, a 2 MW turbine with 115 meter rotor diameter. ReGen is a market leader in Sri Lanka and foraying into Bangladesh.

ReGen an ISO 9001, ISO 14001 and OSHAS 18001 certified company, offers total turnkey solutions for wind power projects that includes consultancy, manufacturing, supply, erection, commissioning, and operations and maintenance services of Wind Energy Converters (WEC).

Mr. Madhusudan Khemka is heading the ReGen as Managing Director. He has over two decades of long and rich experience in all aspects of wind energy converters such as manufacturing, marketing and project management. Mr. Khemka holds a Bachelors degree in Commerce from University of Punjab. He is technically inclined and possesses in-depth knowledge of the scientific aspects of the business.

Mr. R. Sundaresh is taking care of the ReGen as Joint Managing Director having over two decades of experience in corporate finance, corporate affairs, law & general management and vast experience & expertise in raising financial resources in the domestic and international market. He holds a Post Graduate degree in Commerce from the University of Madras and is a qualified Company Secretary.

ReGen has also launched a unique Wind-Solar Hybrid system, first of its kind in the world, solar panels (200 KW to 1000 KW) can be added in the foot print of the wind turbine and run as a hybrid system using the existing land and evacuation infrastructure including the converter of the wind turbine, making the solar installation cheaper by 15-20% compared to stand alone solar plants.

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

WINDERGY INDIA 2017

EXHIBITION & CONFERENCE

windergy INDIA 2017

WIND POWER FOREVER

IWTMA INDIAN WIND TURBINE MANUFACTURERS ASSOCIATION

&

GWEC GLOBAL WIND ENERGY COUNCIL

INDIAN WIND TURBINE MANUFACTURERS ASSOCIATION

GLOBAL WIND ENERGY COUNCIL

announce

WINDERGY INDIA 2017

Conference: 11th and 12th January 2017,
Exhibition: 10th, 11th and 12th January 2017
at The Ashok, New Delhi

POWERING THE WORLD DIFFERENTLY

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

April - May 2016
Date of Publishing : 25.05.2016