Welcome to India

Introduction of the Indian Wind Energy Sector

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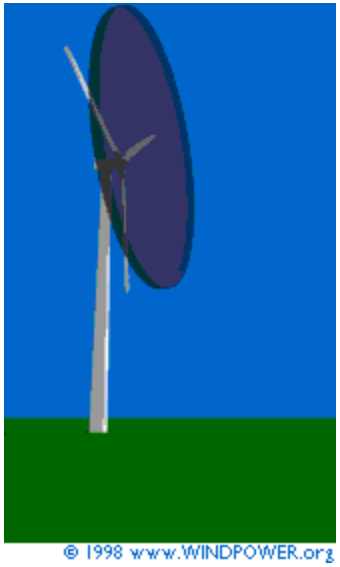


Renewables in India

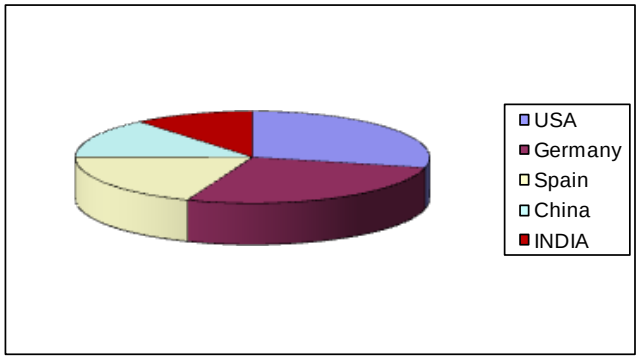
- Wind
- Solar
- Fuel Cell
- Biomass/Bio-methanisation
- Geothermal
- Hybrid
- Cogeneration

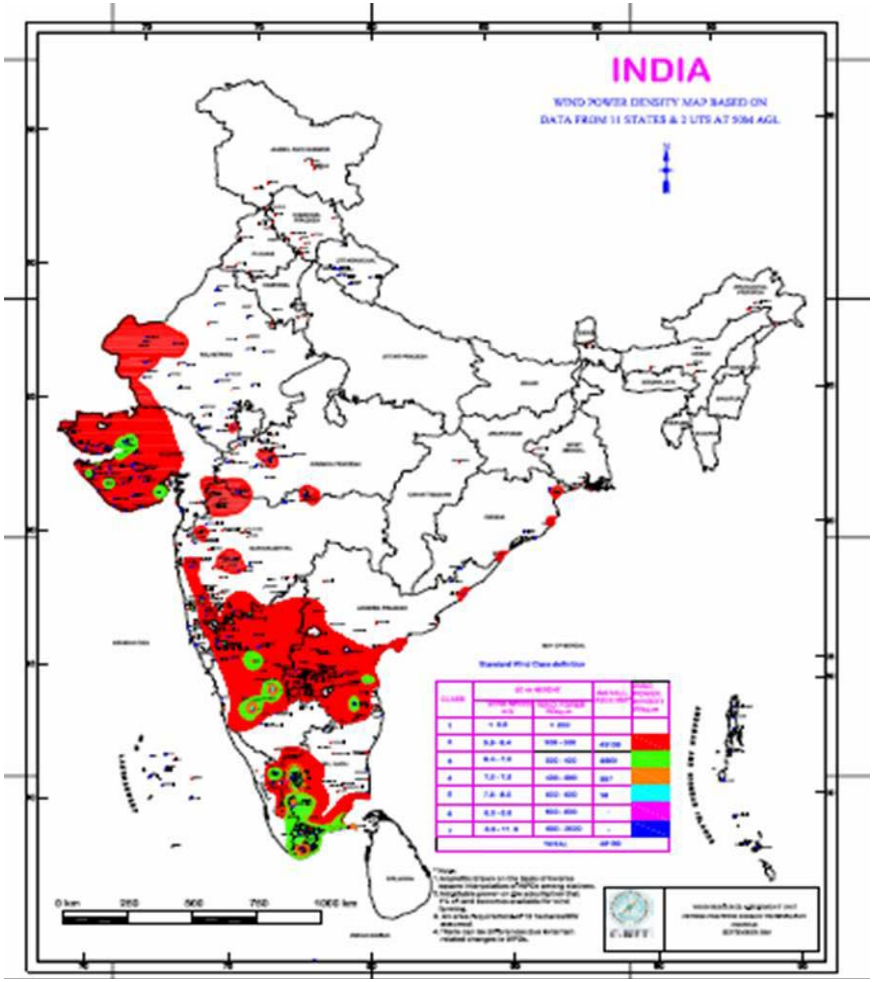
Global Wind Power & India

AS ON DECEMBER 2008

Installed capacity

USA	25170	MW
Germany	23903	MW
Spain	16754	MW
China	12210	MW
INDIA	9654	MW
NOW	(> 10242	MW)





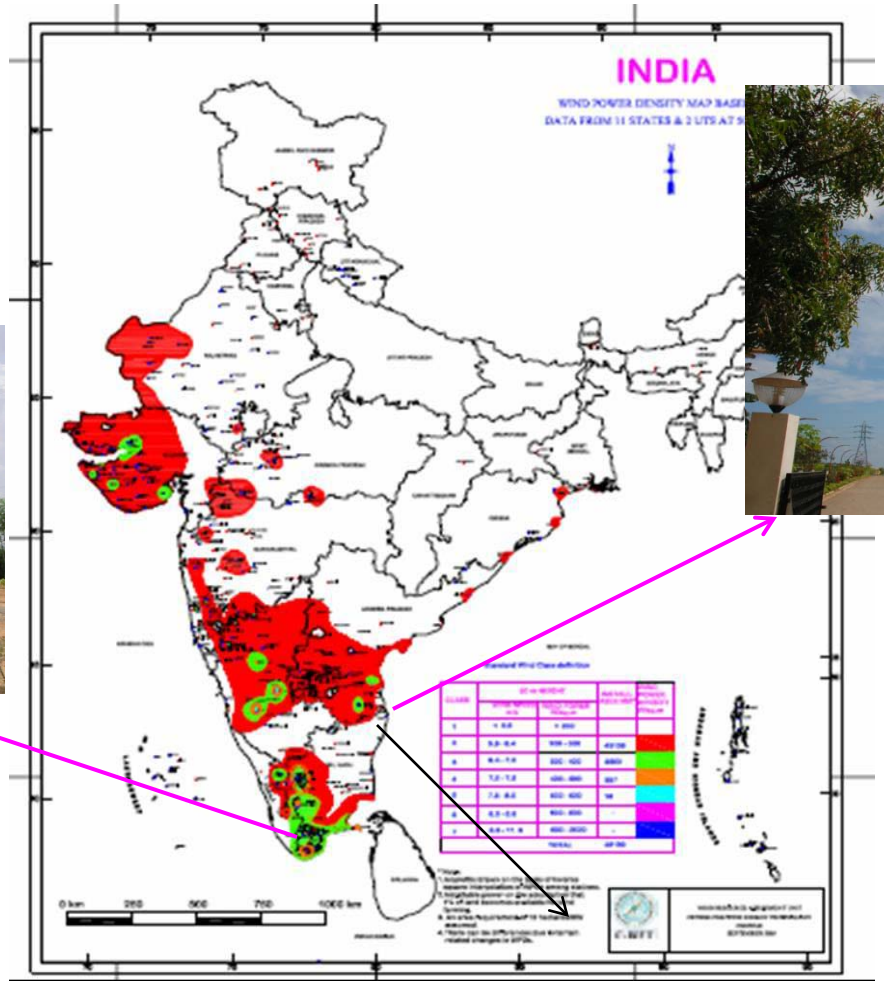
Wind installed capacity state wise

State	Gross (MW)	Tech (MW)	Installed (MW)
Tamil Nadu	5200	> 3200	> 4200
Maharastra	3650	3060	1756
Gujrat	9675	1900	1252
Karnataka	6620	1310	1011
Rajasthan	5400	1050	539
Andhra pradesh	8275	2110	123
Madhya pradesh	5500	1050	188
Others	..	..	14.6

Sustaining Wind Power

- Fiscal/financial incentives
- Manufacturing facility development incentives
- Wind resource assessment
- Wind turbine testing
- Certification and standardization
- Human resource development and training
- Infrastructure /optimum land use
- Power evacuation/Grid management
- Domestic wind generation

C-WET in INDIA



Role of C-WET in Wind Power

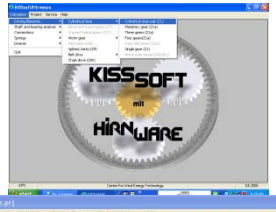
R&D

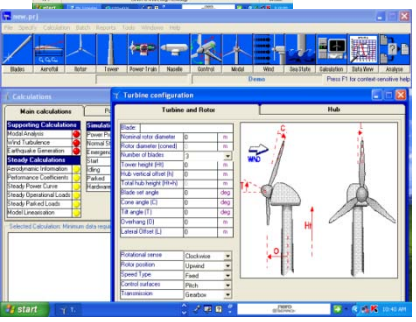
WTT

WRA

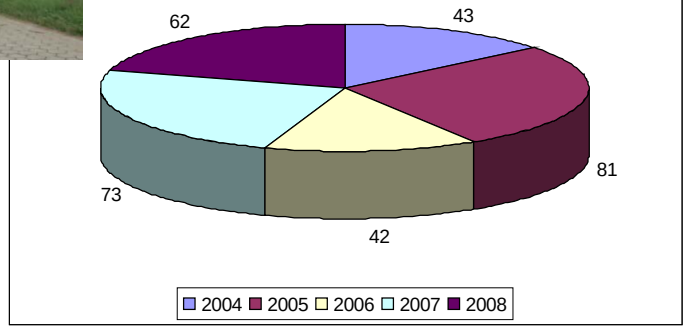
Sectors	200 4	200 5	200			
Developers	16	15	13	24	22	**90**
Manufacturers	12	23	14	23	22	**94**
Utilities		5	2	2	0	**9**
Academicians	1	15	2	12	8	**38**
Government	6	13	9	8	4	**40**
Consultants	5	4	1	2		**12**
Finance	3	2		2	6	**13**
Total	**43**	**77**	**41**	**73**	**62**	

S&C





ITCS



Indian Wind Power

- Wind Resource (Nature)

  Availability, adequacy, steady, sufficient duration, land use & prediction (human)

  +

- Wind Energy Equipment (Human)

  Efficient design, energy capture, ensuring availability, controllable, easy maintenance

Wind Farm Micrositing

- Wind to water 0.0025 to 0.005 %
- Measurement parameters
- Data acquisition, reduction, analysis
- Wind speed map (observed wind climate)
- Wind Atlas
- Micrositing (may need microsurvey too)
- Wind forecasting

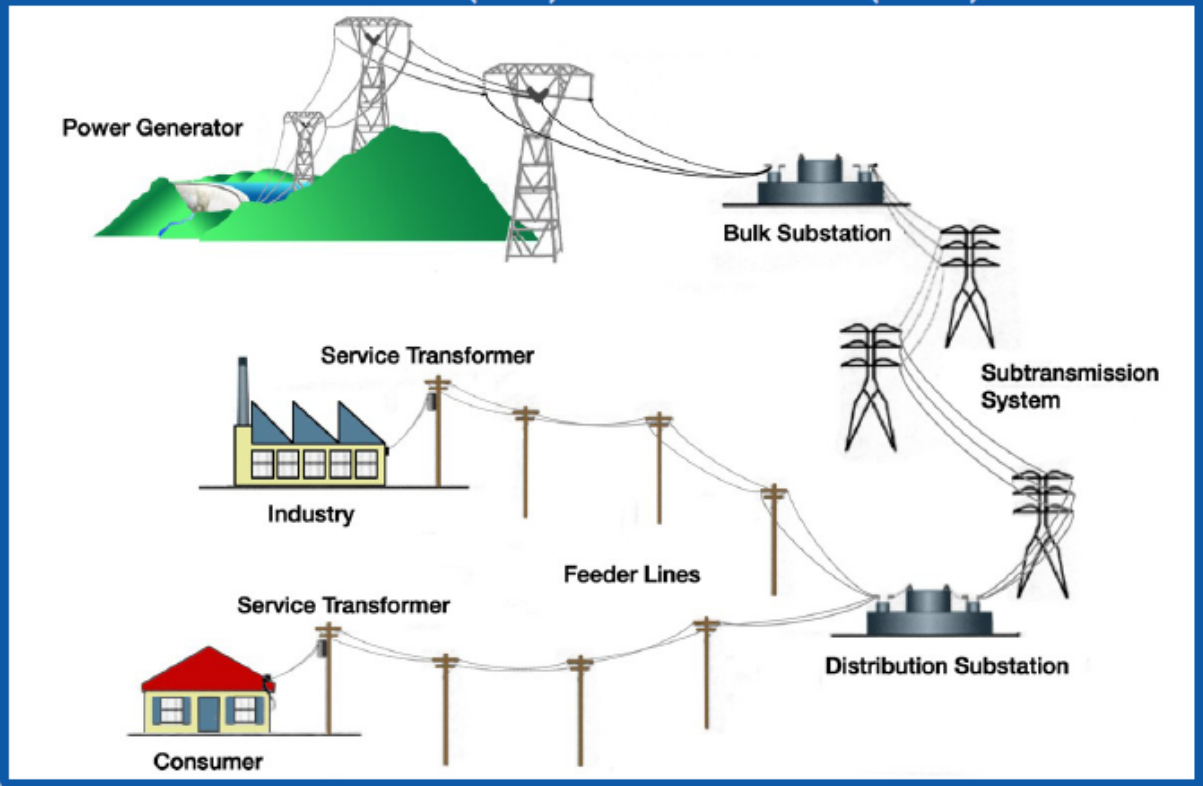
Central and distributed

The IEC View of Electrical energy...

Rotating machinery (TC 2)

Hydraulic turbines (TC 4)

Overhead lines (TC 11)



Overhead electrical conductors (TC 7)

Systems aspects for electrical energy supply (TC 8)

Switchgear and controlgear (TC 17)

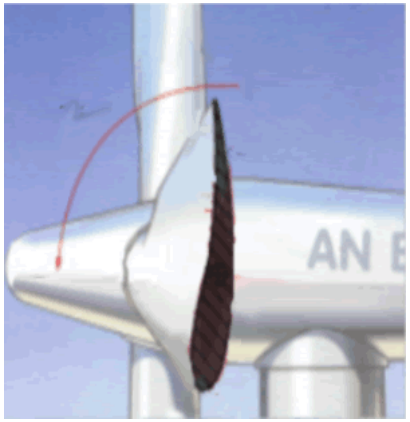
Electric cables (TC 20)

Insulators (TC 36)

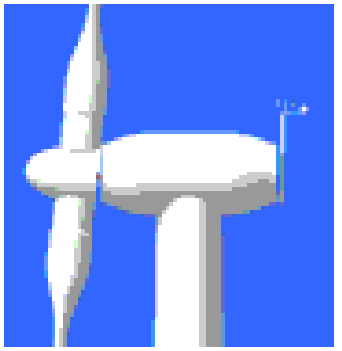
Surge arresters (TC 37)

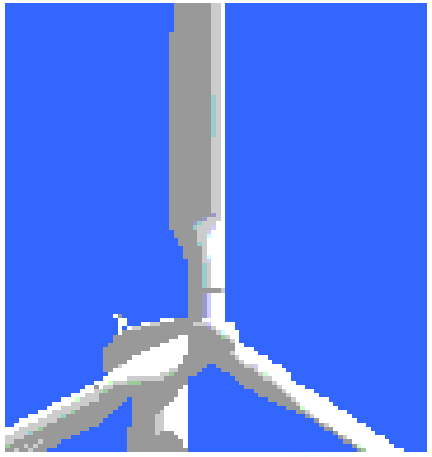
Power systems management and information exchange (TC 57)

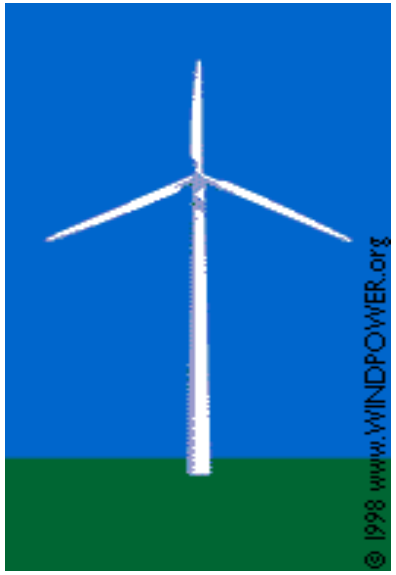
Wind turbine operations



Dynamics of WEGs







Wind turbine Testing (IEC61400)

- Power performance
- Safety and functionality
- Load measurements
- Yaw efficiency

- Blade testing
- Power Quality measurements
- Acoustic Noise measurements

Wind Technology Options

- **Wind electric Generator(WEG) capacity and rotor sizes**
- **Cost effective easy maintenance type of generators**
- **Gear train systems with and without gears**
- **Features for semi/fully converted grid integration**
- **Wind power regulation passive to active controls and switching from stall to pitch**
- **Rotor speed from constant to variable operations**
- **Power electronics for reactive power reduction and for SCADA/remote monitoring**
- **Low maintenance and high reliability**
- **Interfacing turbine operation with online wind forecasting/load schduleing**

Wind Technology Options

- **Wind electric Generator(WEG) capacity and rotor sizes**

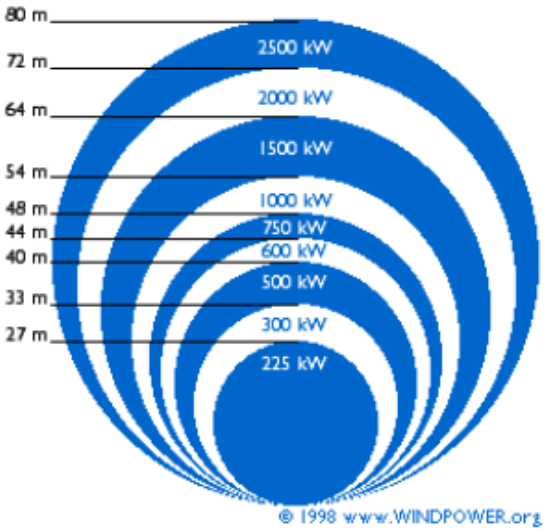
Power and Energy in Wind

Turbine output effectively increases as the square of the diameter, e.g.,

D1 = 25 m, P1= 225 Kw
D2 = 50 m, P2= ?

P2 = $(50/25)^2$ x P1
= 900 kW

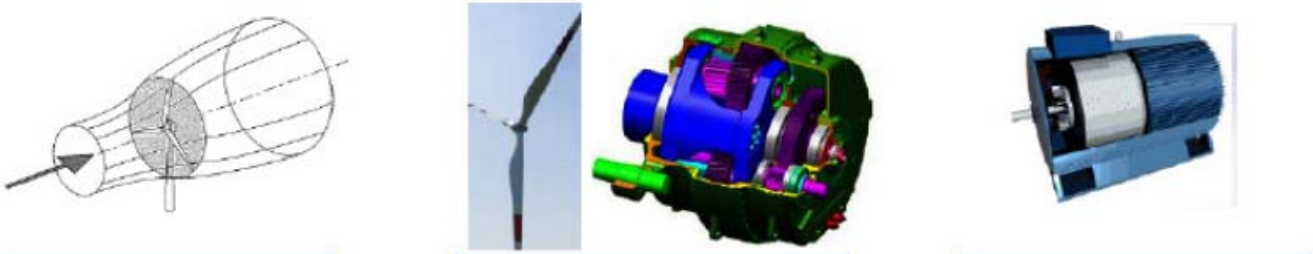
Actual turbine output will vary somewhat due to specific design features and turbine performance



Wind energy Conversion

Wind turbine principles

The basic idea is to convert one energy form into another



Kinetic Energy → Mechanical Energy → Electrical Energy

Rotor 45 - 52% | Gearbox 95 – 97% | Generator + Power Converter 90 – 95%

42 – 50% Efficient Today… Theoretical Maximum is 59% (no losses)

Sub-systems

- Kinetic Energy to Mechanical energy
- Low speed shaft
- Gear system
- High speed shaft
- Mech to Electrical
- Generator
- GRID

VARIABLE SPEED

CONSTANT SPEED

DD-PMG

DFIG

GEARLESS

SYNCHRONISD (AC-DC-AC)

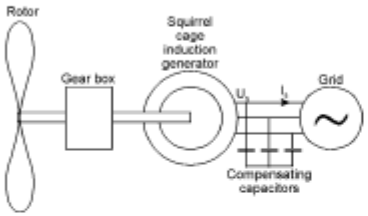
INDUCTION (AC-AC)

220 Volts 50 Hz

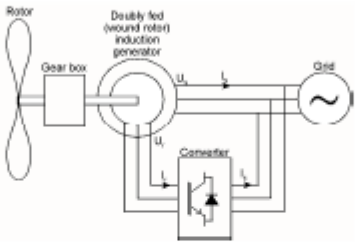
110 Volts 60 Hz

Generators

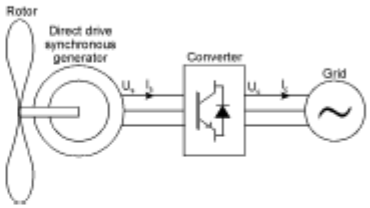
Wind Turbine Concepts



Danish concept, constant speed



Doubly fed induction generator, variable speed



Direct drive synchronous generator, variable speed

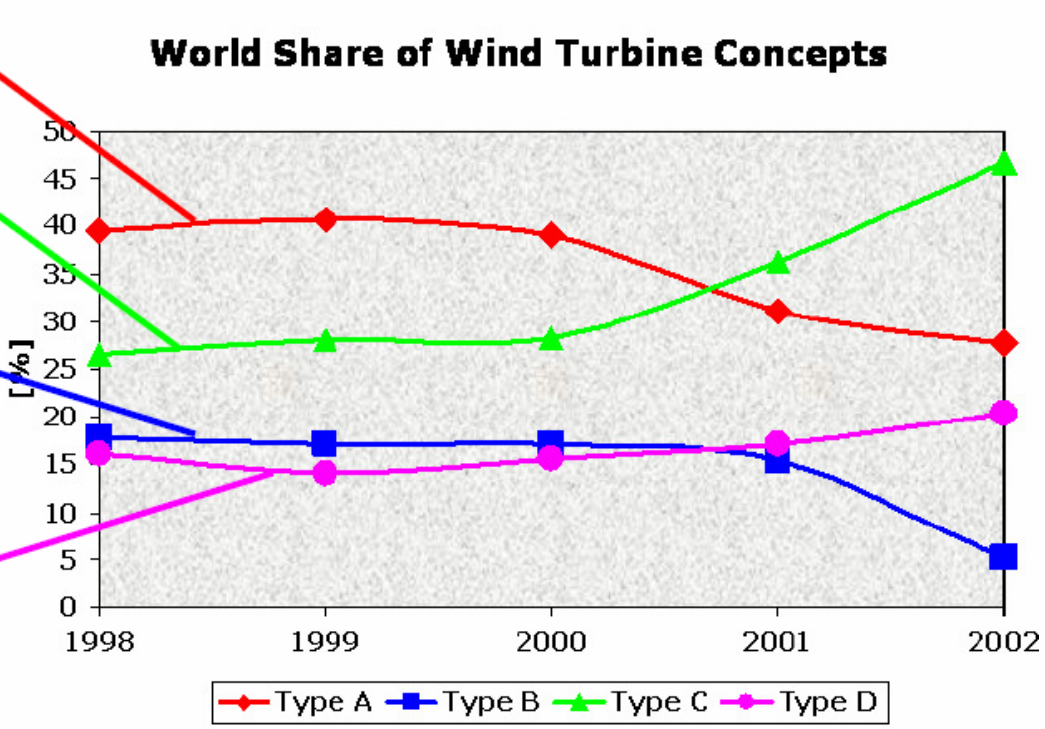
Shift in Tech

Fixed speed

DFIG

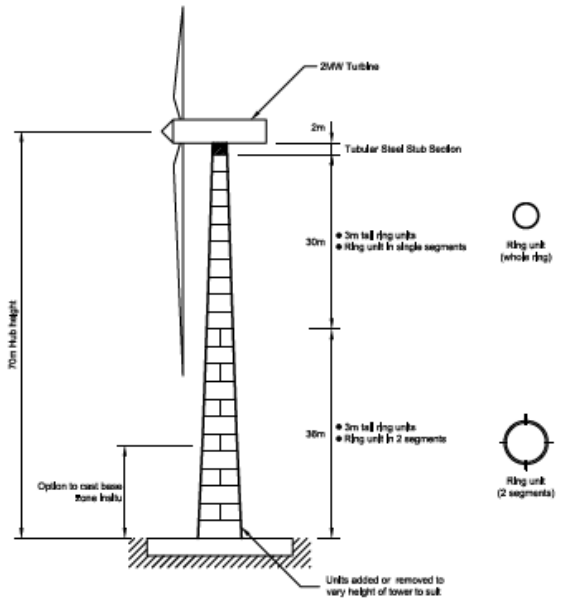
Rotor Resistance Control

Full Scale Power Converter



- Power electronics is now in wind turbines

Tower options



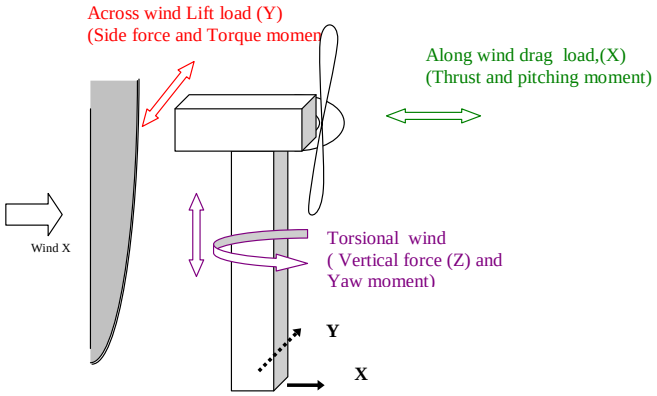
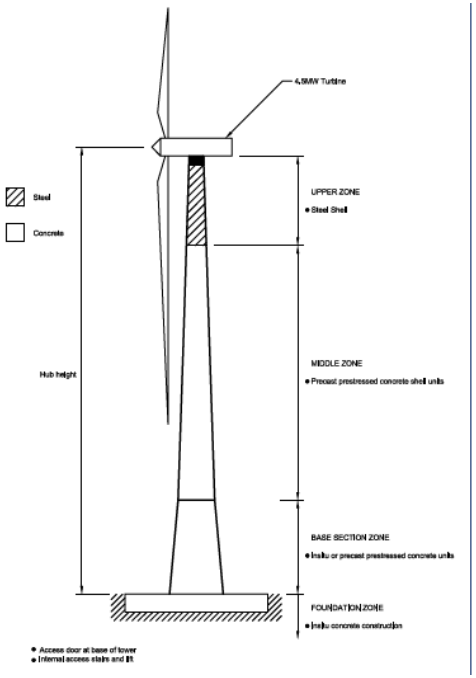


Fig.1 Dynamic wind load effects on wind turbine towers



(Bromage and Tricklebank, 2007)

AREA	Current STATUS	Desired CHANGE
Resource	Gross-potential	Microzonation for accuracy
Private investments	Tax/incentive driven	CDM/generation/green Energy/Quality
Manufacturing	From foreign IPRs/DWG	Indigenous Design capability
Competition	Cut-throat	Open-Consortium
Health-monitoring	minimal	Learn from failures
R&D & innovation	In closed doors	A consortium and industry supported
Small wind/Hybrid	Stand alone	Net-metering
GRID code	Not mandatory	Power Quality/GRID Stability

Acknowledgements and references

www.indiawindpower.com
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www.mnre.gov.in
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