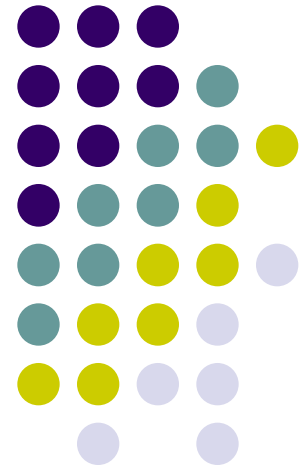
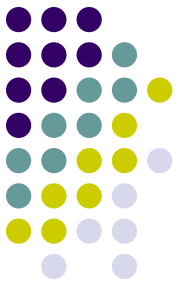


# Wind Energy

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**Centre for Wind Energy Technology**





# Overview

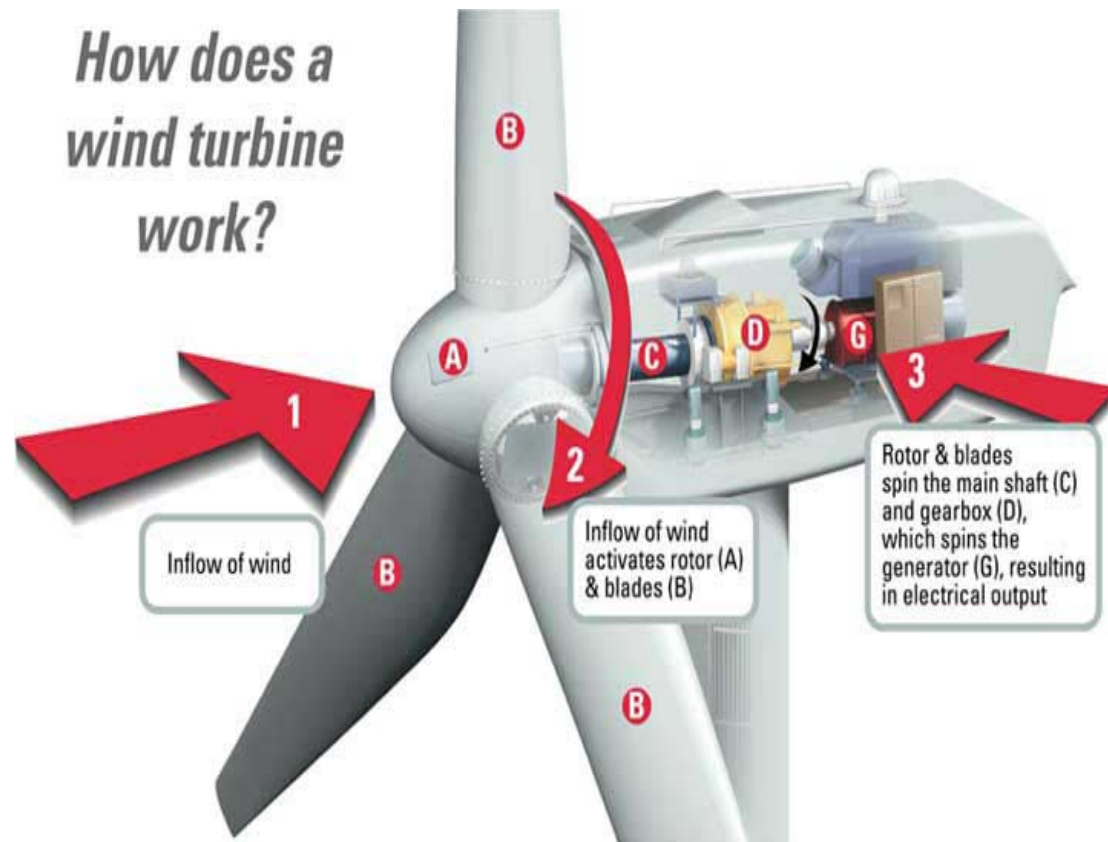
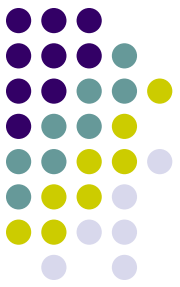
- Introduction: Wind energy
- Technology Trends
- Wind resource assessment
- Wind farm design
- Wind power development in India
- Way Ahead



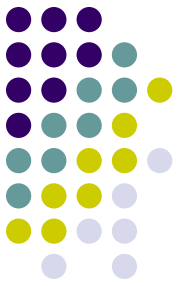
## Wind energy- facts

- Fastest growing and the largest renewable energy source in India
- Emerging as an economically competitive source of energy
- Global installed capacity 160 GW
- Top five countries : USA, Germany, China, Spain and India

# How does a wind turbine work ?



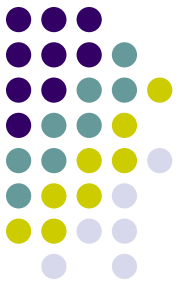
# Wind Turbine Technology



## Challenges

- Meet the grid requirements- satisfy the grid requirements in terms of power quality and reliability of supply
- Design to cope with the variable nature of wind- should operate for wind speeds ranging from cut in (3-4 m/s) to cut off (15-20 m/s)
- Compete economically with other sources of energy- have come at par with conventional source of energy with increased efficiencies and increase in fuel prices.

# Wind Turbine Technology Options



- Vertical axis versus Horizontal axis



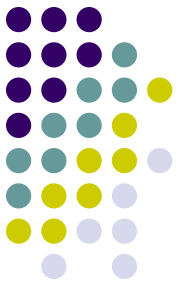
## Vertical Axis Wind turbine

- Advantages – Omni directional with generating equipment at tower base
- Used only for small systems as aerodynamically inefficient

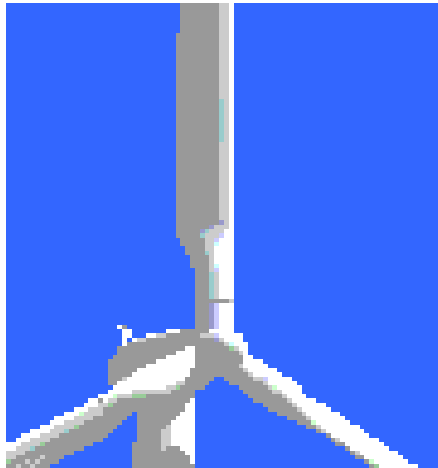
## Horizontal Axis Wind turbine

- Commercial scale wind turbines
- Three bladed upwind configuration most commonly used

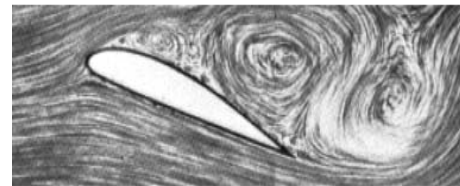
# Wind Turbine Technology Options



## ● Pitch versus Stall



*Attached flow around a profile*



*Separated flow (stall) around a profile*

Two mechanisms to limit rotor power at wind speeds above the rated - pitch and stall regulation

### Pitch regulation

- Wind turbine rotates about the axis of the blade and regulates the power extracted by the rotor
- Used in combination with variable speed turbines.

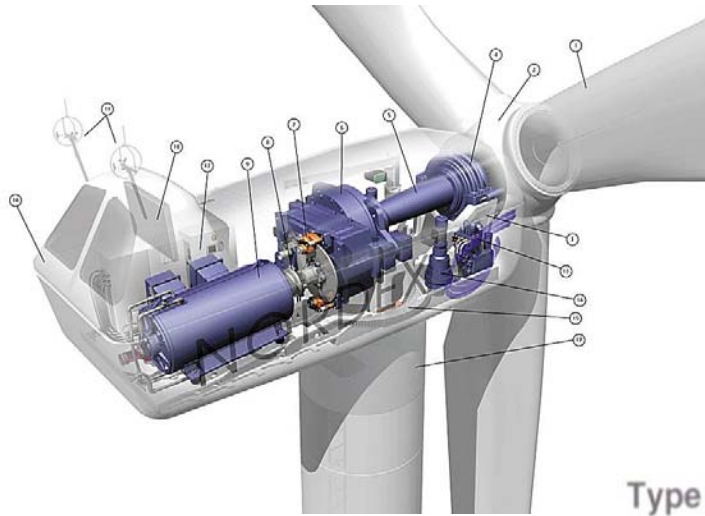
### Stall regulation

- Blade profile so designed that when wind speed increases with rotor speed constant, the flow angle over the blade increases and causes flow separation.

# Wind Turbine Technology Options



## Conventional fixed speed machine



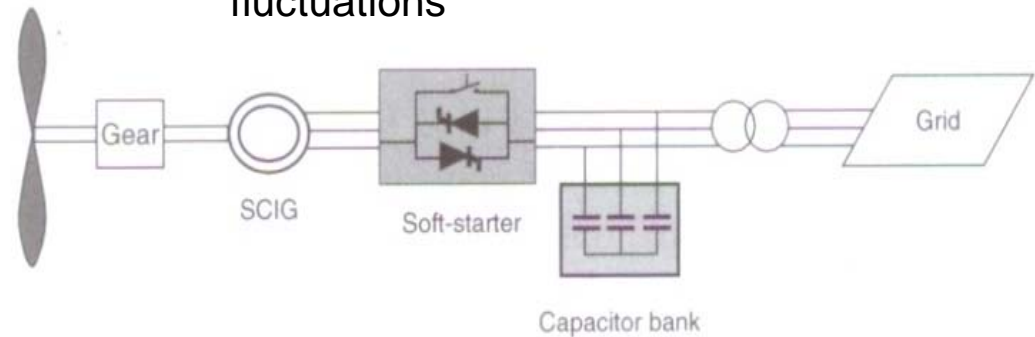
- Consist of rotor coupled to a squirrel cage induction generator through a gearbox.

- Direct connection to the grid

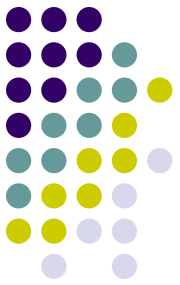
- Capacitor bank for reactive power compensation

- Wind speed fluctuations cause power fluctuations

Type A



# Wind Turbine Technology Options



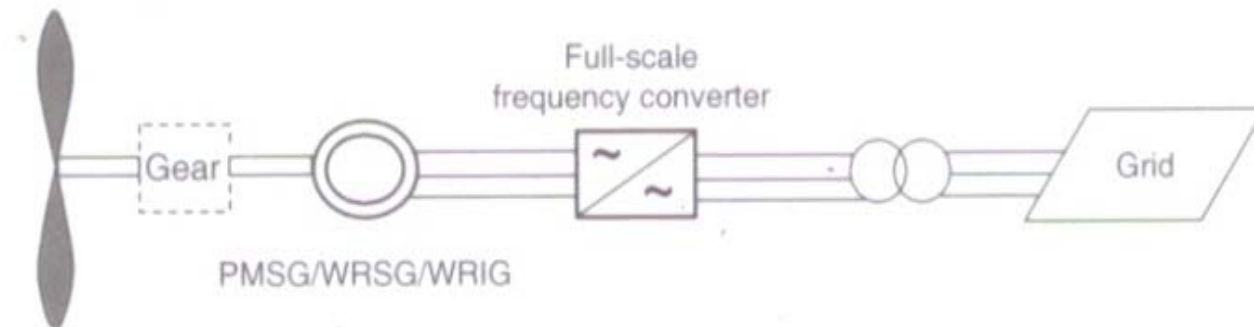
*direct-drive variable speed alternator*

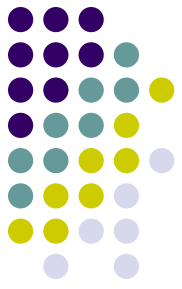


([www.enercon.de](http://www.enercon.de))

- Consist of rotor coupled to a synchronous generator/ doubly fed induction generator directly or through a gearbox
- Connected to the grid through a frequency converter, which decouples the generator from the grid and allows variable speed operation.
- Variable speed operation below rated wind speed increases energy capture and substantially relieves load above rated wind speed.

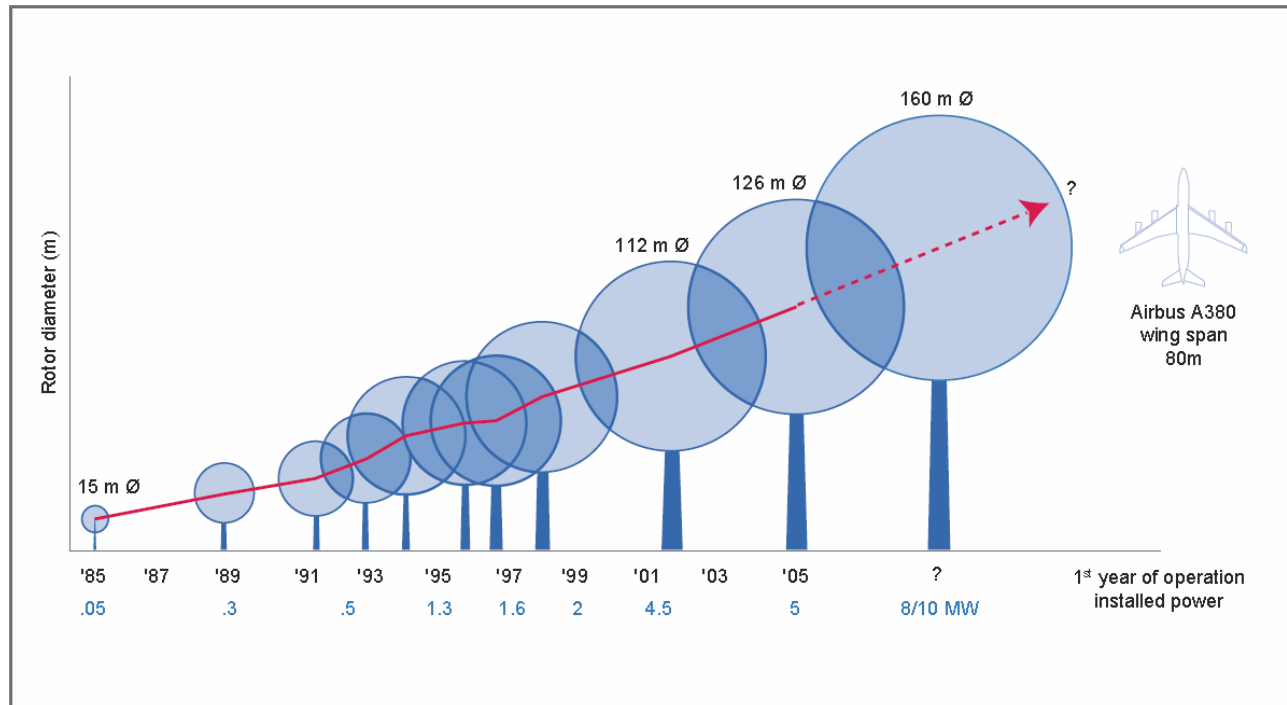
Type D





# Growth in size of commercial wind turbines

- Wind Turbine Technology has seen two major changes over the years
  - There has been a steady increase on the unit sizes.
  - The original fixed stall – induction generator based technology has given way to very sophisticated high end products.

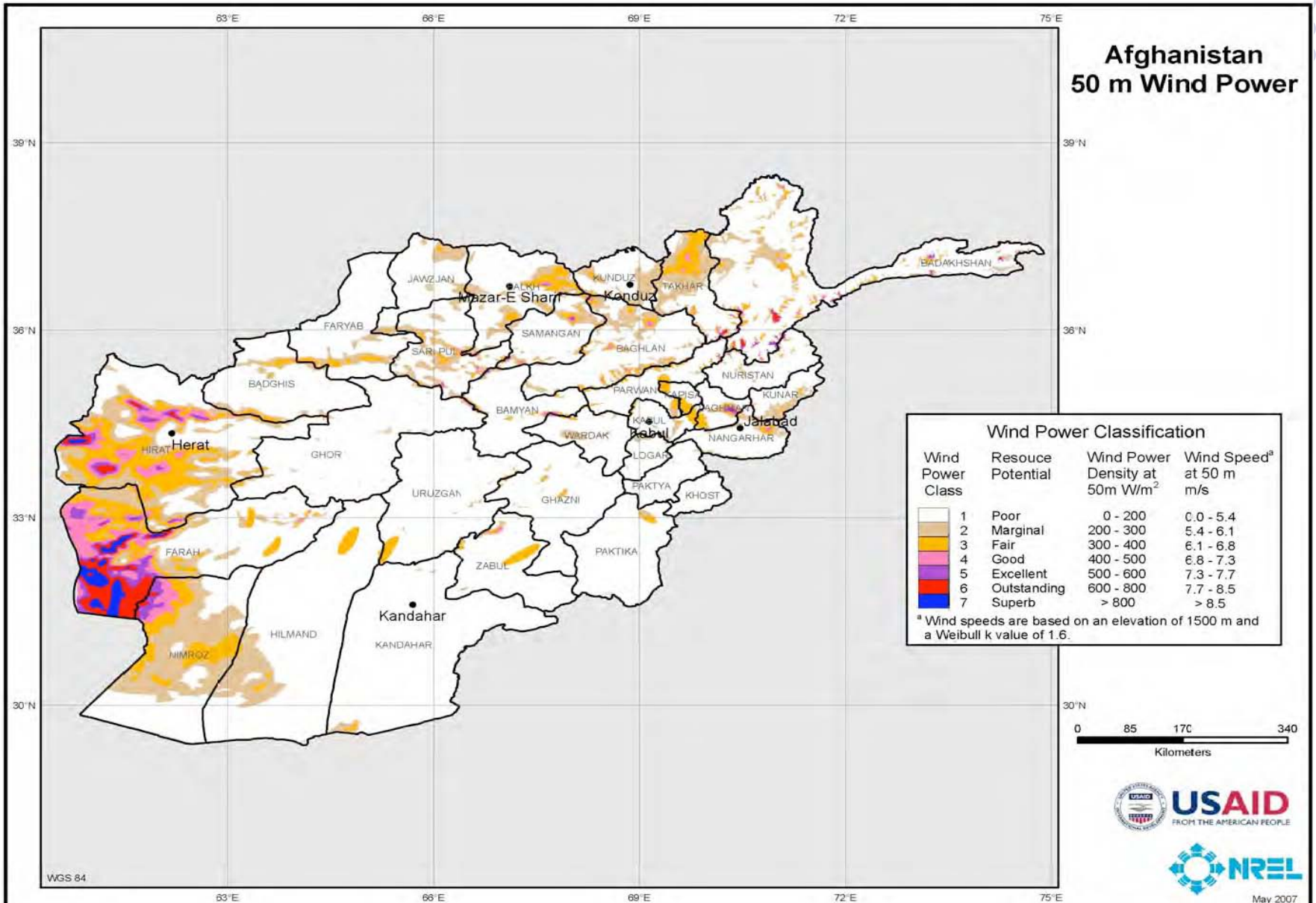


# Wind Resource Assessment



- Regional Wind resources
  - On site measurement
    - Accurate , but time consuming
  - Computer modelling
    - Determines the mean wind speed on a broader scale – wind atlas
- Local wind resource assessment
  - Essential before wind farm development is undertaken at a site
  - Helps in determining the expected long term energy production

# Wind Atlas



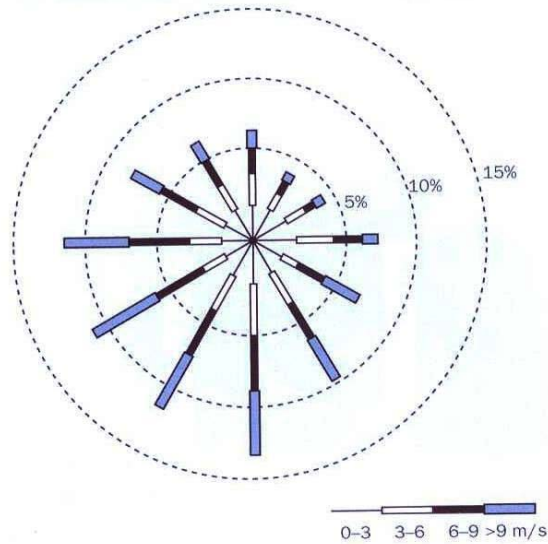


# Wind Resource Assessment

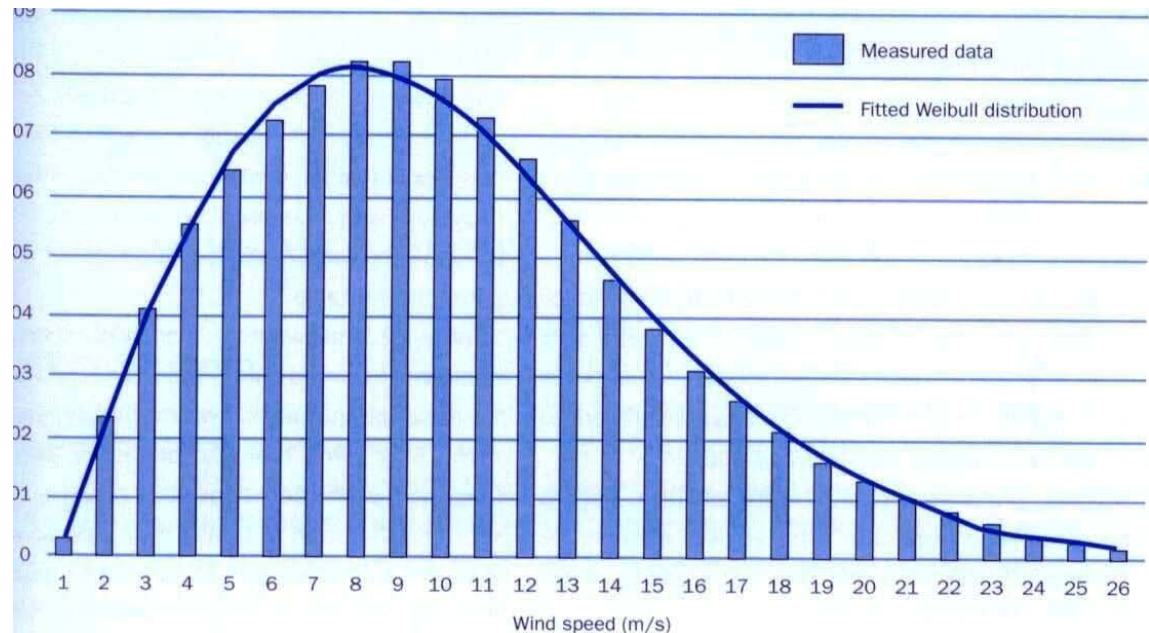
## Annual variability of wind speed

-Wind rose

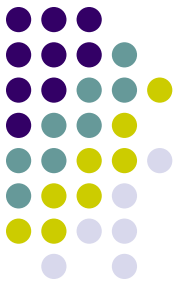
-Wind speed Distribution



Source: Garrad Hassan



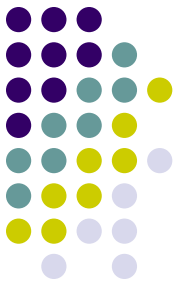
# Wind resource Assessment



## **Prediction of energy production of a wind farm**

- Wind farm layout and hub height
- Wind turbine characteristics
- Topography of the site
- Predicted long term air density and turbulence intensity of the site

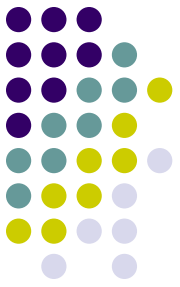
# Small Wind Turbines and Hybrid systems



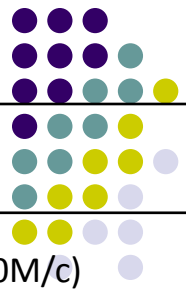
- Rotor swept area  $< 200$  sq.m
- For isolated applications at sites with good wind resources
- Can work in both off grid and grid connected applications

# Wind farm design

- Identifying suitable sites based on wind resource data
- Site design and micro-siting
- Land acquisition
- Site Development
- Infrastructure
- Approval from designated authority
- Erection and Commissioning



# Wind Power Development in India



Sl. no	Factors	Incubation	Infancy	Consolidation	Growth
1	Size of windfarms	very small (<5M/c)	small (<25M/c)	Moderate (<50M/c)	High (>100M/c)
2	Machine capacity	55kW /110kW	<300kW	<600kW	800kW to 2.1MW
3	Tower type	Lattice	Sheet steel	Steel	Steel / Concrete
4	Hub height	30M	30M	50M	50 to 75M
5	Connectivity	LT lines / Distributed	11kV Feeders	11kV Feeders/ small dedicated substations (66 or 110kV)	Dedicated 220kV substations
6	Investor type	Govt. agencies	Individual investors	Small corporates	Large corporates / Private Utility companies / FIIs
7	Purpose	Demonstration	Accelerated depreciation	Accelerated depreciation/ Wheeling & Banking	Accelerated depreciation, Wheeling & Banking / IPP / CDM
8	Cost per Unit	NA	High (affordable mainly due to subsidies)	Moderate (affordable partly due to subsidies)	Highly competitive
9	Investor confidence	NA	Low	Moderate	High

Courtesy: Historical development of wind – N. Ramani

# India: Central & State Government Policy Highlights



- 80% accelerated depreciation
- Excise duty/import tariff concessions
- Tax holiday for power generation
- Feed-in tariffs
- Provision of banking, wheeling and third party sale of power
- Other financial incentives/subsidies in certain states

# India: New initiatives

- Renewable Energy Purchase Obligations
- Generation based incentives for grid connected wind power projects
- Guidelines for wind measurement by the private sector



# Way Ahead.....



- **Assessment of wind power potential in the country and identify suitable sites for wind power projects**
- **Setting up of demonstration wind farm projects with a view to creating awareness of new technologies**
- **Promotional policies for creating a conducive environment for private sector participation**
- **Promotion of small wind turbines for off grid applications.**