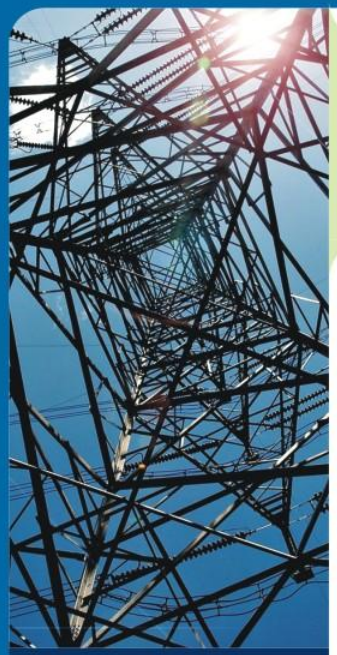
9th International Training Course on Wind Turbine Technology and Applications

For 2nd Philippine Wind Energy Stakeholders Meeting at the Asian Development Bank (ADB)

Prepared by:
Mr. Rommel E. Reyes

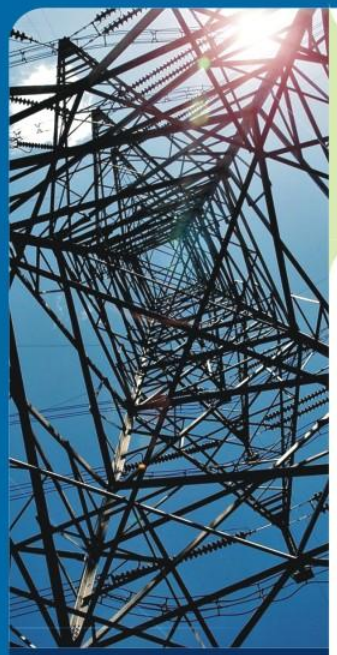


Presentation Outline

- Introduction
  - Indian Energy Sector
  - About CWET
  - 9th International Training Course
- Wind Energy Preliminaries
- Wind Resource Assessment
- Forecasting
- Grid Integration
- Conclusion

*The contents of this presentation are obtained from CWET's Wind Turbine Technology and Applications Training Course.

Introduction



Indian Wind Energy Sector

- Fifth largest wind power capacity in the world
- About 8% of country's total installed capacity
- 23 large wind turbine manufacturers
- Installed wind capacity of 17,875 MW as of July 2012

Indian Wind Energy Sector

Installation and Generation Cost

Source	Installation Cost	Cost of Generation*		Phil. Approved Fit Rates
	(Crores of Rs./MW)	(Rs./kWh)	Coverted to PhP**	Php/kWh
Wind Power	5.00 -6.00	4.00 – 5.00	3.19-3.99	8.53
Bio mass Power	4.00 -5.00	4.00 – 5.00	3.19-3.99	6.63
Small Hydro	5.00 - 6.00	3.00 – 3.50	2.39-2.79	5.9
Solar PV	9.00 -10.00	10.00 - 12.00	7.975-9.57	9.68
Energy from waste	5.00 - 10.00	4.00 – 7.50	3.19-5.97	-

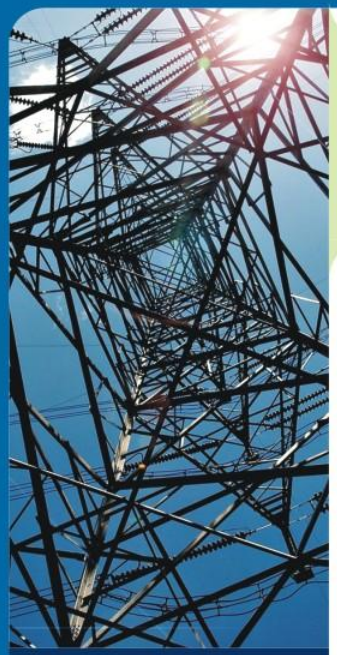
*Tariff differs from each state

**1.25 Rs: 1 Php

Indian Wind Energy Sector

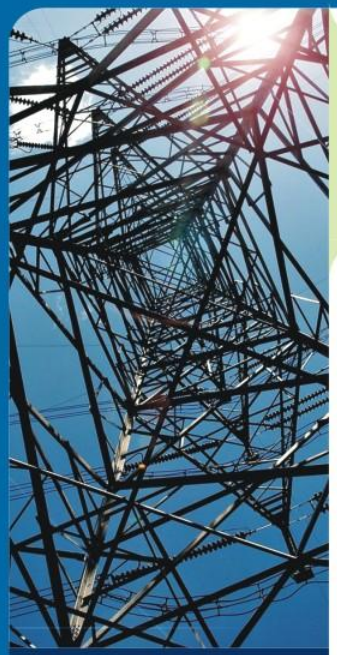
Potential & Achievement

Source	Potential in MW	Achievement in MW
Wind Power	49,000	17,875
Small hydro Power	10,000	3421
Waste to Energy	2,700	94
Co-generation Bagasse	5,000	2,079
Bio-mass Power	16,880	1,192
Solar PV Power	----	1,040
Total		25,701



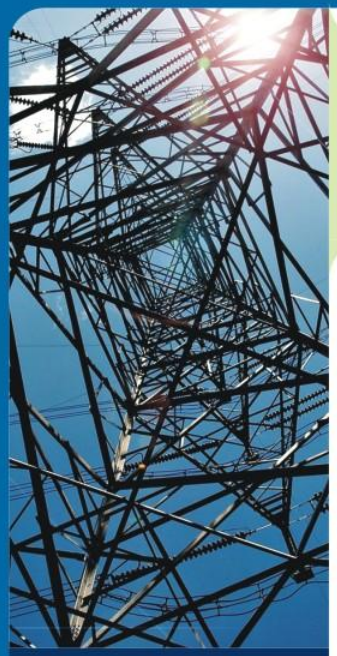
About CWET

- The Centre for Wind Energy Technology (CWET) is an autonomous R&D body of the Ministry of New and Renewable Energy (MNRE)
- Established in 1998 in Chennai, India
- Has the objectives of wind resource assessment, wind turbine testing and certification, preparation Indian standards, research and development



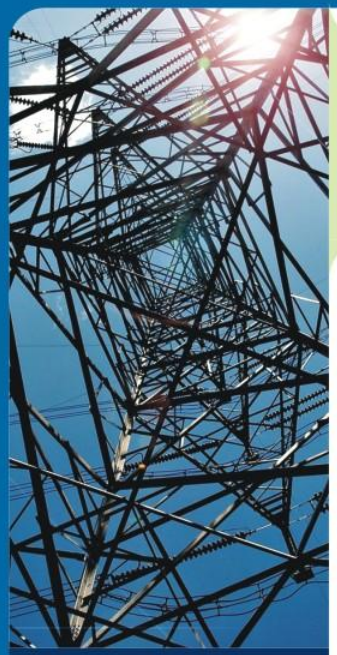
About CWET

- Another objective is providing information, training and commercial services including information dissemination
- Conducted trainings since 2004 for more than 900 participants
- Expert lecturers: CWET Scientist, Industy Professionals, Goverment and Academia



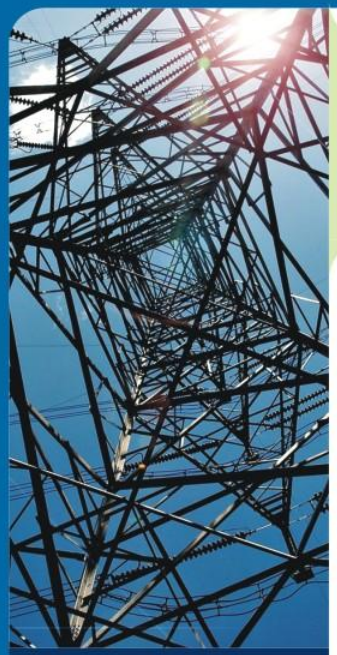
9th International Training Course

- The course was scheduled from 5-27 September 2012
- Participants from 21 countries
- Other than class room lectures, it included hands-on working with wind energy equipments, excursions to operating wind farms and wind turbine manufacturing facilities



9th International Training Course

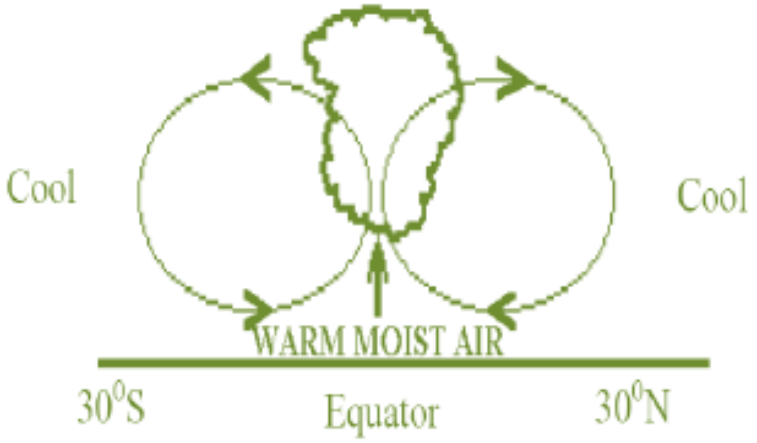
- Wind energy conversion technology and power generation
- Assembly / design of wind turbine
- Wind turbine components and performance characteristics
- Wind turbine technology developments
- Wind resource assessment and techniques
- Planning including design of wind farms
- Cost benefit analysis of wind energy projects Installation and commissioning of wind farms
- Post installation activities – Grid integration
- O & M aspects of wind farms
- Testing & Certification of wind turbines
- Small wind turbine and hybrid systems
- Indian government policies, schemes and legal frameworks
- Wind energy developments in India
- CDM related to wind energy development

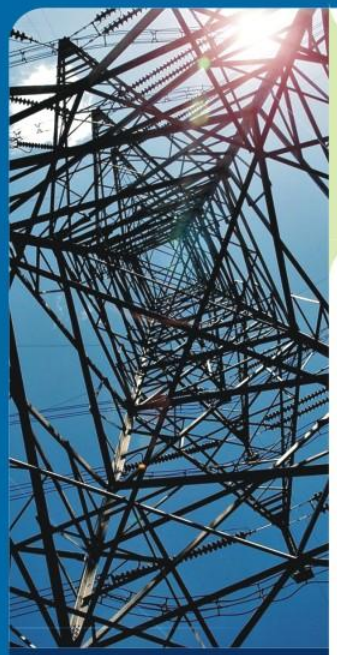


Wind Energy Preliminaries

Wind Energy Preliminaries

- Air in motion i.e. motion of air relative to the earth's surface.
- Free, clean and inexhaustible energy
- It will vary place to place and time to time





Wind Energy Preliminaries

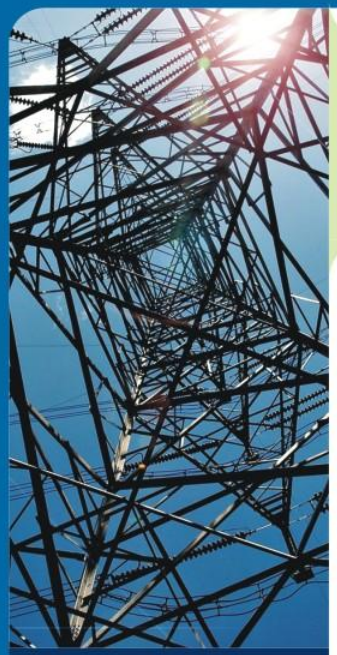
From Wind to Electric Power

Power (translation) = Force x Velocity (P=F V) or
Power (rotation) = Torque x rotational speed (P=T x rpm)

Power (Energy) = KE*m
KE Kinetic Energy ,
m mass flow rate

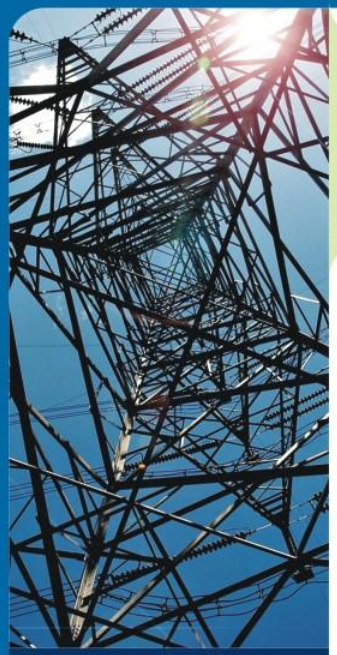
Pwind = Cp 1/2 p V^3 A
Cp efficiency (“Betz” max. = 16/27)
p Air density (~1.22 kg/m3)
V Wind speed
A Gross rotor area

Wind Resource Assessment



Wind Resource Assessment

- Wind resource assessment (WRA) is the practice of collecting wind data to evaluate the wind resource at a site.
- The main objective of WRA program is to identify potential windy areas in a region for developing wind farm projects.



Wind Resource Assessment

- Economic feasibility of a wind farm at any location depends on wind resource available
- There is no substitute for actual measurement
- Accurate and thorough monitoring of wind resource at a location is a critical factor.

Wind Resource Assessment

- Minimum measurement duration is 1 year for on-shore site and 5 years for off-shore.
- The core of the monitoring program is collecting the time series data:
  - Wind Speed
  - Wind Direction
  - Temperature
  - Pressure
  - Solar Radiation

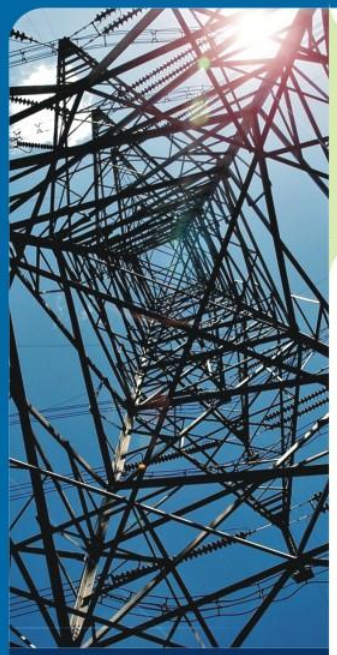
Wind Resource Assessment

From the time series data we can derived the following Parameters

DATA ANALYSIS

- Turbulence Intensity
- Energy Pattern Factor
- Air Density
- Wind Power Density
- Power law Index

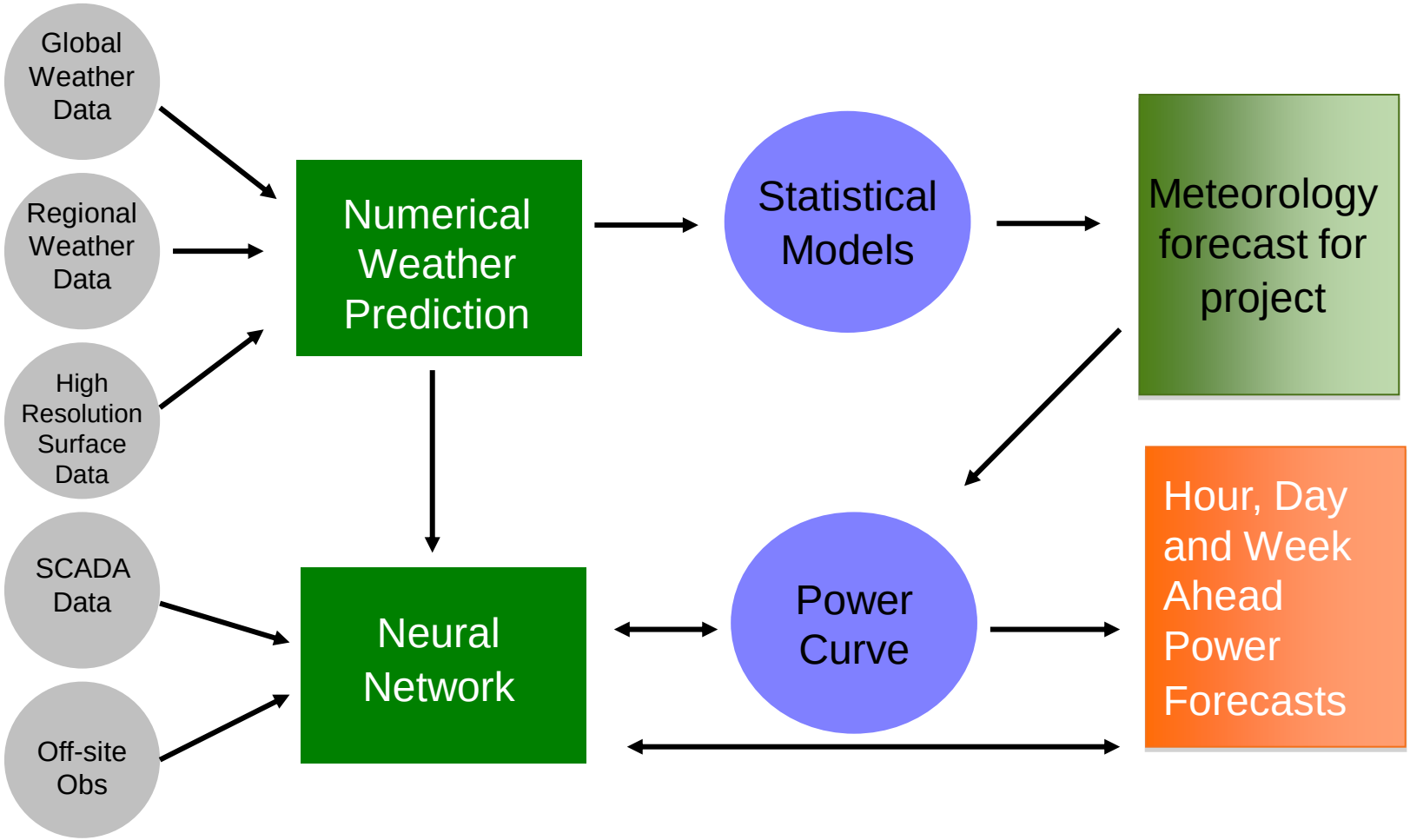
Wind Forecasting



Wind Forecasting

- As wind is an intermittent resource, weather changes can cause large and rapid changes to the wind farm output
- This requires rapid dispatching of generation and transmission resources to balance generation versus load, voltage and frequency, and maintain system performance within the required limits
- With wind forecasting, wind farms and power utilities can plan its Availability

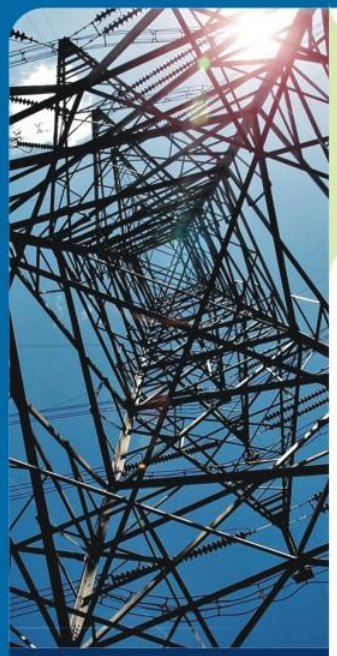
3TIER Preparatory Wind Energy Forecasting System



Wind Forecasting

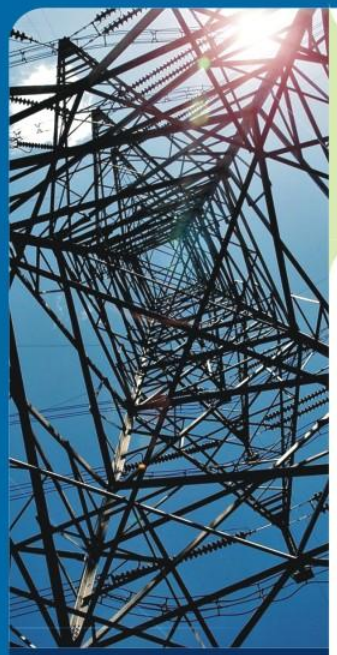
- 100% accuracy cannot be expected, but modern forecasting systems provide about 15-25% percent error for hour ahead and 40-50% percent error in day ahead

Wind Forecasting



- In India, wind generators (10MW and above) are responsible for forecasting their generation up to an accuracy of 70%. Beyond this, the wind generator will bear the unscheduled interchange (UI).

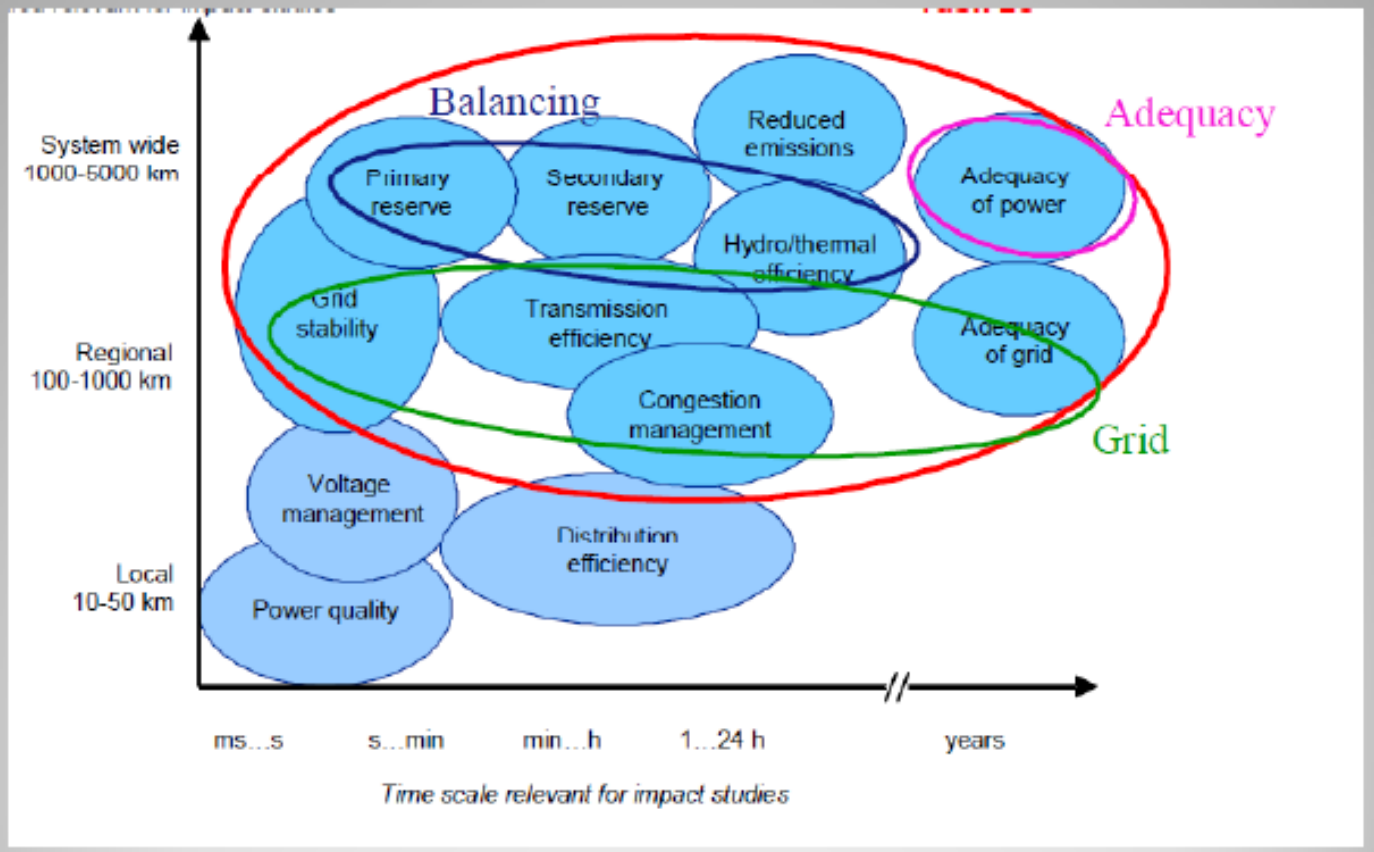
Grid Integration

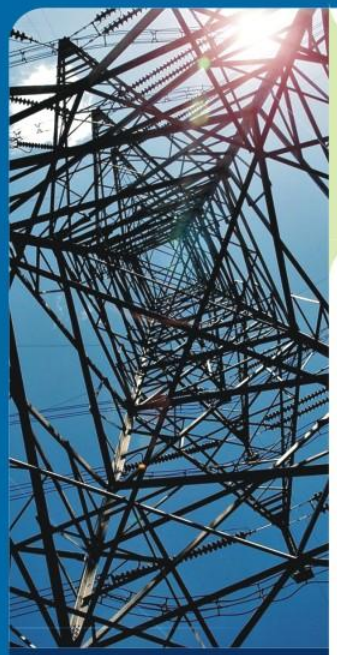


Grid Integration Issues

- Technical performance of the wind turbines
- Meteorological and geographical conditions
- Grid stability
- Balance and reserve power
- Power evacuation

Grid Integration Issues

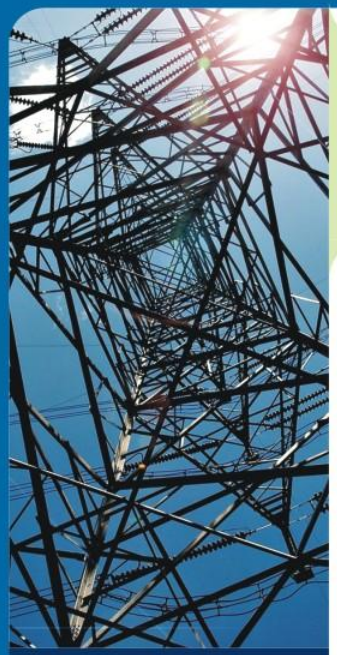




Grid System & Properties

Short Circuit Power level

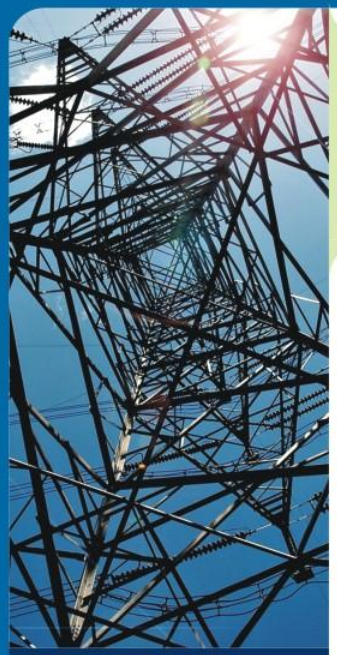
- Measure of electrical strength of a circuit
- Determines the effect of the turbine on the steady state voltage
- Voltage deviation at the wind turbine terminals is directly proportional to the ratio of rated apparent power of the turbine to the short circuit level.



Grid System & Properties

Short Circuit Ratio

- The ratio of the apparent power of the turbine to the short circuit level at the point of connection
- Should be at least 50 times that of the rated power of the wind farm
- Generally ratio below 20 may mean a weak grid
- If weak grid system
  - Use appropriate reactive power compensation of fixed speed wind turbines.
  - Use of wind turbines with controllable power output.
  - Reinforcement of the grid.



Power System Requirements

Active power control

- To ensure stable frequency, prevent overloading of transmission systems and avoid in- rush currents during start up and shutdown.

Frequency control

- Power output of a wind farm may have to be controlled depending on grid frequency.

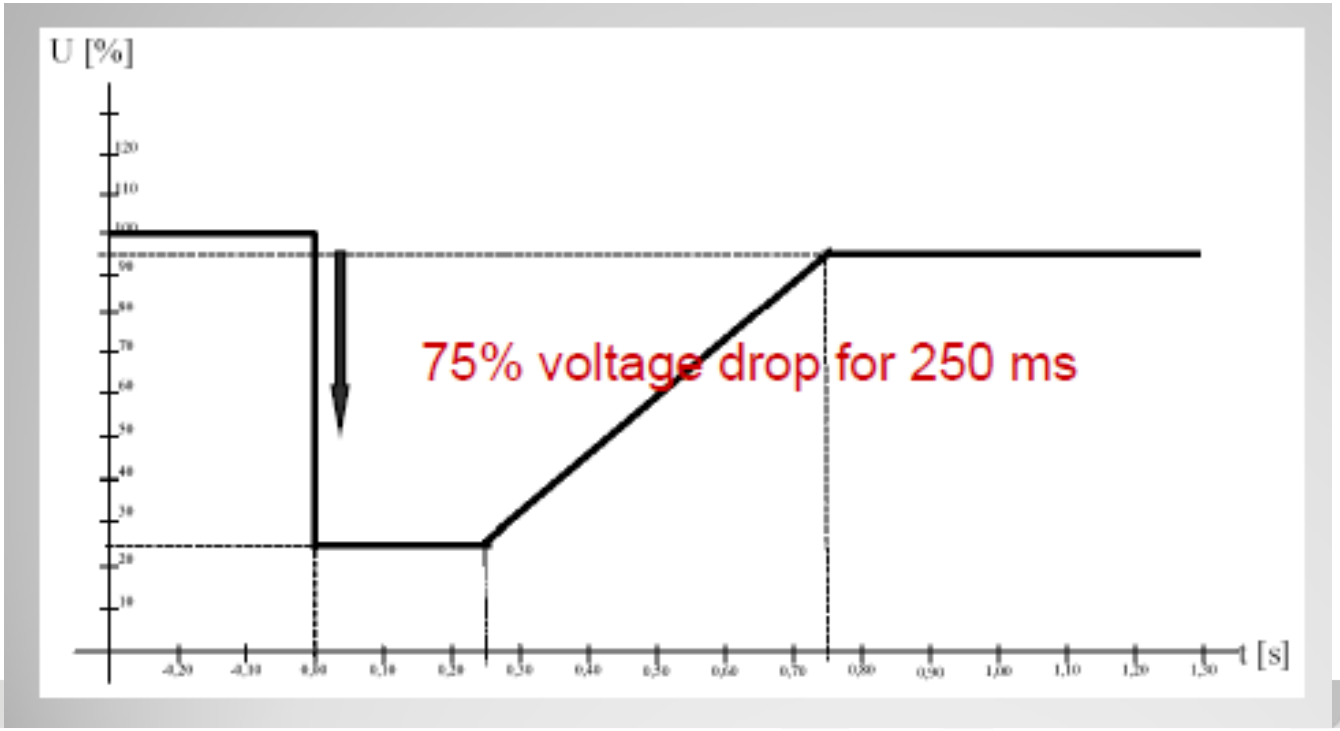
Voltage control

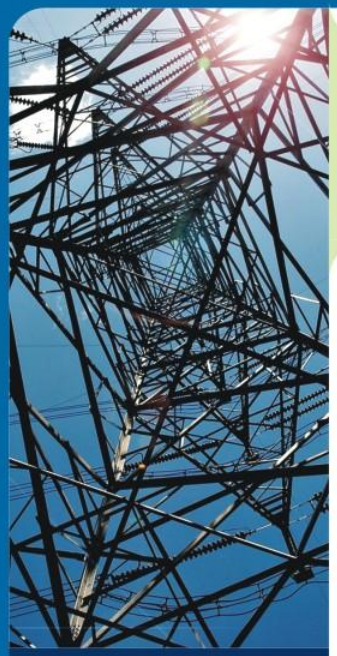
- To ensure voltage at PCC is maintained within acceptable limits as required for utility and customer equipment.

Power System Requirements

Fault ride through recovery

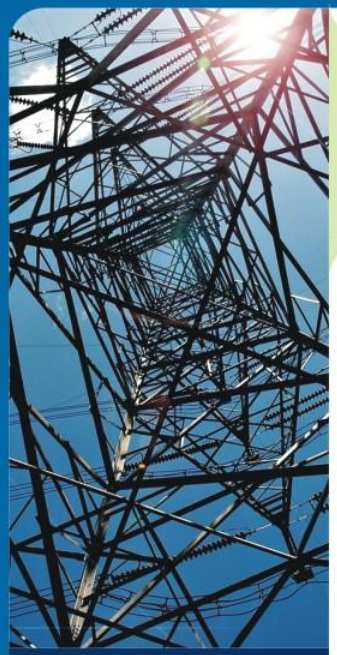
The wind turbines must be able to continue uninterrupted operation under a transient voltage variation similar to the one illustrated below





IEGC 2010 requirements

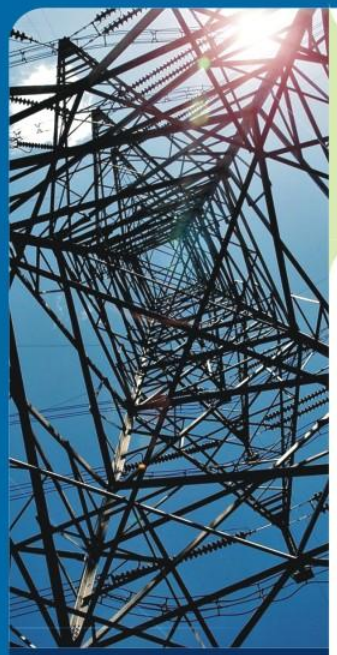
- Wind power to be treated as must run station
- Control of reactive power drawn / injection into the grid.
- Reactive power drawn during wind generator start up
- Wind energy forecasting/ scheduling of wind generation



IEGC 2010 requirements

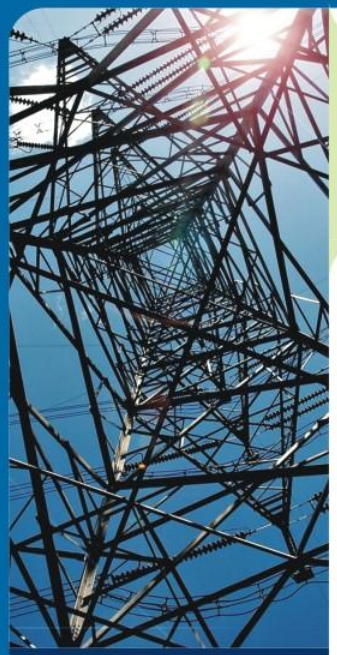
- Day ahead forecasts of wind power at 15 minutes interval for the next 24 hrs for aggregate generation capacity of 10 MW and above at 33 kV or above.
- Wind generators shall forecast their generation with an accuracy of up to 70 %.
- Wind generation shall bear the UI charges if the actual generation is not within these accuracy levels.
- Host state shall bear the UI charges for variation within ±30 %.

Schedule (MW)	Actual generation (MW)	Implication on purchaser	Unscheduled Interchange (UI)	
			Implication on host state	Implication on wind generator
100	60	To pay for 70 MW to wind generator (since, in this range, the wind generator comes under UI mechanism) at contracted rate. 30 MW by purchaser at UI rate in his Region, to RRF	Out of 40 MW liability of UI on Host State on account of under generation by wind generator, UI for 30 MW shall be received by the host state from RRF and UI of 10 MW would be received from the UI pool.	UI rate for 10 MW payable by Wind Generator to UI Pool



Conclusions

- There is no substitute for actual measurement for assessing wind resource
- Minimum measurement duration is 1 year for on-shore site and 5 years for off-shore.
- Forecasting is an essential tool to aid the integration of the increasing amount of wind energy.



Conclusions

- Forecasting helps make wind farm appear more like a conventional power station.
- Must dispatch for wind is possible if there is proper forecasting
- Grid integration of wind turbines should consider properties of point of connection, impacts to the power system, reactive power compesation schemes and interconnection standards.

C-WET

9th International Training Course on
WIND TURBINE TECHNOLOGY AND APPLICATIONS
5th to 27th September 2012

THANK YOU!

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CENTRE FOR WIND ENERGY TECHNOLOGY (C-WET)
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