Electrical Aspects of Wind Turbines

Prof Peter Tavner
Electrical Parts of the Wind Turbine

- Generator
- Converter
- Power Control
- Cables
- Transformer
- Power Collection
- Lightning Protection
1887, Cleveland, USA

- Inventor, Charles Francis Brush
- Manufactured, Cleveland USA
- Turbine Dia 17m
- 144 blades
- 10 rev/min, variable speed
- Power Output, 12kW
1980, California, USA

- Result of Californian environmental laws
- Small turbines <100kW
- Turbine diameters, 10-15m
- 70-80 rev/min, depending on turbine design, fixed speed
- Poorly sited
- Blade failures common
- Disastrous reliability
2003, Modern Product

- Manufacturer, DeWind
- Manufactured, Loughborough, UK
- Turbine Dia 70m
- 3 blades
- 17 rev/min, variable speed
- Power Output, 2 MW
# Types of Turbine & their Control

<table>
<thead>
<tr>
<th>Speed Control</th>
<th>Pitch Control</th>
<th>Power Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed speed/Dual</td>
<td>None</td>
<td>Passive stall regulation geared drive train with asynchronous generator</td>
</tr>
<tr>
<td>speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed speed</td>
<td>Yes, pitch to stall</td>
<td>Active stall regulation geared drive train with asynchronous generator</td>
</tr>
<tr>
<td>Limited variable</td>
<td>Yes</td>
<td>Geared drive train with asynchronous generator control using variable rotor</td>
</tr>
<tr>
<td>speed</td>
<td></td>
<td>resistance</td>
</tr>
<tr>
<td>Variable speed</td>
<td>Yes</td>
<td>Geared drive train with slip ring asynchronous generator control using a partly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>rated converter</td>
</tr>
<tr>
<td>Variable speed</td>
<td>Yes</td>
<td>Direct drive with synchronous generator control using a fully rated converter</td>
</tr>
</tbody>
</table>
Types of Turbine & their Generators
Changing Technology

Supergen Wind Educational Seminar
Induction Machine

Supergen Wind Educational Seminar
Induction Machine
Induction Machine

Graph showing the relationship between torque and current with labels for Locked Rotor Current, Breakdown Torque, Pull-up Torque, and Full Load Torque. The graph also includes a note about Synchronous Speed, which depends on the machine's pole pairs and gearbox ratio.
Induction Machine

Synchronous Speed
Depends on machine pole pairs and gearbox ratio

Figure 7.30  Variation of Reactive Power with Slip for a 1 MW Induction Machine
Fixed Speed Turbine
Induction Generator
Variable Speed
Broad Speed Range
Variable Speed
Narrow Speed Range
Variable Speed Turbine Converter
Variable Speed Turbine
Geared Drive
Induction Generator
Fully Rated Converter

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Variable Speed Turbine
Induction Generator

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Geared Wind Turbine
Induction Machine
Geared Wind Turbine
Doubly Fed Induction Machine
Geared Wind Turbine
Doubly Fed Induction Machine
Direct Drive Wind Turbine
Direct Drive Wind Turbine
Power Collection

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Figure 10.2  Transformer and Switchgear of 1.5 MW Wind Turbine. MV Switchgear on right, LV Switchgear on left (Reproduced by permission of NEG MICON; www.neg-micon.dk)
Power Collection Offshore
Maintenance Offshore
Thank you


