The Parts of a Wind turbine, Construction and Integration

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• The elements of a wind turbine
• The construction of the wind power plant
• The building procedure
• Integration of wind energy into bulk power systems
Growing unit performance

Today:
120-160 m
3.5-5 MW
Limits: the sky

Source: Adapted from EWEA (2009).
Parts of a wind turbine:

- Rotor blades
- Anemometer
- Generator
- Turning generator house
- Steel tower
- Low-med. volt. transformer
- Cable
- Power electronics
- Grid
Foundation

- on-shore
- plates
- poles

- off-shore
- floating
- mast weighted
Transportation
Craning
Nacelle
## Trends

<table>
<thead>
<tr>
<th></th>
<th>traditional</th>
<th>up-to-date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tower</td>
<td>steel</td>
<td>concrete</td>
</tr>
<tr>
<td>Height</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>Rpm</td>
<td>semi fixed</td>
<td>variable</td>
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<tr>
<td></td>
<td>speed</td>
<td>speed</td>
</tr>
<tr>
<td>Cut in</td>
<td>3m/s</td>
<td>2,5m/s</td>
</tr>
</tbody>
</table>
E-40 – E-82
New control paradigm: wind priority

**Traditional control:** Load demand $\rightarrow$ generation control on the base of the demand

**Wind priority:** we let generate all the wind plant, and we produce some more by the request

**Future:** intelligent generation and load harmonisation (Demand Side Management)
New control paradigm: wind priority

Traditional:
Control by the demand
• E.g. steam generation
• Turbine
• Generator

Wind:
Control by the wind speed and demand
• rotor blades
• generator
Indirect and direct driving
Connection of the generator to the grid

Appr. RPM
900-1000 changing

Fixed frequency (RPM)
Control: pitch, P,Q
Electrical connection: compact substation
Connection to 20 kV
Single line scheme
More details...
Protection, measurements, settling, RTU
Connection between the tower and the compact substation
Power, voltage level and topology

- 1 unit: cca. 2 MW (0.8 – 3.5 MW)
- 20 kV for transmission 3-8 MW
- Wind park: 20-30 units -> 110/120 kV
- Special topologies: ring, tree, quadratic, meshed, etc.
- Security – geography – economy – ecology
Wind speed changes
by Jensen

\[
\frac{v_{\text{estela}}(d)}{v_0} = \frac{1}{2} + \frac{1}{2} \sqrt{1 - 2C_T(v_0) \left( \frac{D_0}{D(d)} \right)^2}
\]
„Wind shadow” – Wake effect decreasing speed – decreasing energy (work of Javier Serrano)
Micrositing - optimisation
(work of Javier Serrano)
Quadratic displacement, Burgenland, Austria
Line on the hill edge
Molina *moderna* de Aragón
Near Calatayud, Spain
Near Calatayud, Spain
Near Calatayud, Spain
150 towers on this picture!
Kefalonia, Greece
Measurements
Characteristics, RPM, output power

Cut in

Power out

RPM
Niederland, Cabo Verde, Burgenland (A), Portugal
Windpower plants in Hungary, 2006
Characteristics

- Teljesítmény görbe V90-1,8 MW & 2,0 MW
- Szél
- Lapátszög
- Generátor
Rotor blade

V90 (~44 m)  MD 77 (37,5 m)

6,5 t!

Glassfiber – epoxi

Grafit fiber
Damage on Crete island

- It happens
High security due to individual blade adjustment

Combined planet spur wheel gear for high effectiveness

Large disk brake as 2nd safety system

Variable speed, double-fed asynchronous generator for high profitability

Four azimuth driving motors for safe and stable wind direction tracking

Robust and compact machine support with sound decoupling for the main components
Output curve FL MD 70/77 (measured)

Wind speed [m/s]

Output [kW]

FL MD 77

FL MD 70
CALCULATED POWER CURVE

Power P [kW]

Power coefficient Cp [-]

Wind speed v in hub height [m/s]

E82
Characteristics measurements

<table>
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<th>Wind [m/s]</th>
<th>Power P [kW]</th>
<th>Power coefficient Cp [-]</th>
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„Storm control”

Diagram 1: Power curve of a wind turbine without ENERCON storm control

Diagram 2: Power curve of a wind turbine with ENERCON storm control
## Comparison

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<thead>
<tr>
<th>Szélerőmű típusa</th>
<th>NORDEX</th>
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<td>2290</td>
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<td>Tengelymagasság</td>
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<td>30/40/50</td>
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<td>Járókerék fordulszáma</td>
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<td>1/min</td>
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<td>39.5–29.5</td>
<td>34–18</td>
<td>26.9–17.9</td>
<td>22–16</td>
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</tbody>
</table>
Bükkaranyos
Erk
Mezőtúr
Mosonszolnok
Szápár
Törökszentmiklós
System load <-> wind production

A hazai villamosenergia-rendszer terhelése

Szélerőmű kiadott teljesítménye

Wind Turbine Construction
Balancing with CO₂
Feel the measure!

V27 – 225 kW     E-40 600 kW     E-48 800 kW
Feel the measure!

MD-77 1.5 MW  V-90 1.8 MW  E-70 2 MW
How many tower represents 1000 MW?

<table>
<thead>
<tr>
<th>Model</th>
<th>Power (kW)</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>V27</td>
<td>225</td>
<td>4444 pcs</td>
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<td>600</td>
<td>1666 pcs</td>
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<td>1.5 MW</td>
<td>666 pcs</td>
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<tr>
<td>V-90</td>
<td>1.8 MW</td>
<td>555 pcs</td>
</tr>
<tr>
<td>E-70</td>
<td>2 MW</td>
<td>500 pcs</td>
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</table>

A lot.
Wind energy integration
Energy production calculation

• If 1000 MW built in capacity operates in 1 year with 20 % usage ratio
  
• 365 days x 24 hours x 1000 MW x 0,2 % = 1.752.000 [MWh] = 1,752 TWh

• In Hungary it is only 4,47 % of the total consumption

• Not too much
Power ratio

It is much!


Wind Turbine Construction - Wind energy integration - Patra, 2013
How the wind blows

- BEWAG experiences: gradient 60 MW/h
- 3 areas - 3 different wind blows
- Local autobalancing in the windpark
- Balancing between different areas

http://www.vrbpower.com/
Sudden stop of wind power plants

• Too strong wind (over 25-30 m/s)
• Network faults
• Frequency problems

Is it really problem to loose 200 MW? – daily events

The network flexibility must be raised!

• Diversification
• Forecast
• Fault in Spain

• 2006.11.04.

• Storm in Denmark
The UTSIRA project
Hydrogen generation
Central hydrogen generation – system operator control

ISO control

Wind production
ISO surplus for hydrogen

KÖZLEKEDÉSI
felhasználás
Hidrogén kút
Központi hidrogén előállító szövet
KÖF elosztó hálózat
Rendszerirányítói szabályozás
Wind production
ISO surplus for hydrogen

ISO control

Wind production
ISO surplus for hydrogen

KÖZLEKEDÉSI
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Központi hidrogén előállító szövet
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Rendszerirányítói szabályozás

Wind Turbine Construction - Wind energy integration - Patra, 2013

75
Where to find the control capacities?

Unused controllable capacities

Uncontrolled gas fired capacities
Co-control of gas engines and wind turbines
Wind generation + gas engine generation + balancing

Forecasted wind production
Real production
Planned balance
Gas engine balance
Total production

[kW]

[óra]
Load of the gas engine
Control Center for Renewable Energy (CORE)

- Iberdrola
- Toledo, Spain
- Virtual power plant
- Connection to the ISO
- On-line control of the wind towers
- Maintenance control
What helps the integration?

- Control of the windpark output
- Diversification
- Local control centers
- Intraday power exchange
American plans…

20% Wind Scenario - 305 GW by 2030

Incremental Direct Costs of 20% Wind Vision Scenario

Fuel Savings From Wind

Conclusion

- The wind technology is cleared, this is the high time of the application
- The hot topics are the off shore plants
- The integration of the wind energy is the question of decision
- The present network structures was not planned and implemented for the trade and renewable generation

Have a good work!
Thanks for the attention!