Development of the WWD3 Wind Energy Converter

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Aim:
Developing a wind energy converter of....

1. **High technical reliability using the MULTIBRID concept**
2. **Small developing risk by using already proven component solutions**
3. **Low overall generating costs by long lifetime and reduced maintenance**
4. **Basic data D=90m P=3MW suitable for inland and shore sites**

Solutions:

Machine concept
Integrated structure, slow-speed drive train, MULTIBRID-concept.
Pitch and full range variable speed => Maximum energy capture. Low noise, especially at low wind speeds. Noise-optimum speed curves available, also depending on day/night time etc.

Gearbox
No 1500 rpm- high-speed stage=> avoiding noise and highly stressed parts
Low operating temperature=> well defined oil viscosity, less oil ageing
Oil bypass 4um fine filtering => high lifetime ensured
Low gear mesh frequencies=> no need for an elastic suspension, which may add unwanted dynamics in the drive train
Slip clutch with 1,6 times rated torque=> no overload even in generator short circuit cases

Condition monitoring
Gearbox, main bearing and generator supervised by vibration analysis => additional safety

Bearing
Compact bearing=> well defined flow of forces, low stress and strain, very small drive train deformations.
FEM-analysis of bearing together with gears => compatibility ensured
Oil lubricated => higher lifetime than with grease

Double radial shaft seal plus additional V-ring => reliably tight. The whole seal can be exchanged on site without taking off the rotor.

Generator
Permanently excited => high partial power efficiency, less losses, lower thermal stress
Winding is a preformed coil copper bar winding => high resistance against dU/dt
Low rated speed => low thermal loading, large surface per loss power
Cooling=> water jacket and internal air circulation result in low operating temperature and high lifetime
No brushes => nearly maintenance-free
Bearings are oil lubricated => better reliability than with grease, no maintenance.
The same basic design has been used largely and successfully in ship drives (Azipod) => small developing risk.

Inverter
IGBT's on generator and grid side, switching frequency 2-3 kHz => a minimum of grid reaction, high power quality. E-ON-rules can be fulfilled. The inverter is a series industrial product, modified in detail to match the requirements => small developing risk.

Blades
Glass only, no carbon => clearly defined lightning conductor path. No problems with matching materials of different young's modulus and thermal expansion. Availability and price is steady.

Pitch
Double-layer capacitors instead of lead-acid batteries => no exchange necessary, no acid, no gases.
AC-system, controlled pitch speed during all shutdowns => no undefined speed as with series-wound DC-motor directly switched to batteries.

Yaw
Inverter drives => load reduction by torque limitation and speedup/slowdown ramps

Hub, Gear casing, Mainframe
Globular cast iron GJS 400 18 U-LT => well-known fatigue properties
FEM analysis and optimisation => safe parts

Tower
Site-specific solutions available => optimum economy. Prototype has for example a base diameter of 5 m, because transport was possible. Standard hub height is 90m.

Component deliverers for the prototype machine:
Blades => EUROS, Germany/Poland
Cast iron parts => METSO Foundry, Finland
Gearbox => METSO Drives, Finland
Condition monitoring => METSO, Finland
Generator and inverter => ABB, Finland
Tower steel => mostly RAUTARUUKKI, manufacture LEVATOR, both Finland
Main Bearing => FAG, Germany
Yaw and pitch bearings => LIEBHERR, Germany
Yaw and pitch gears => BONFIGLIOLI, Germany / Italy
Pitch drives and electrics => DIPCO, Germany
Brakes => SVENDBORG, Germany/Denmark
Operation control computer => hardware from BECKHOFF, own development

Cooperation partners:
aerodyn GmbH (FEM, tower design, concept licence)
EUROS GmbH (load calculations)
Germanischer Lloyd (machine design assessment), TÜV Nord (tower approval)
DIPCO (control software)
MULTIBRID GmbH (general correspondence)

The first machine is just being assembled in Oulu, Finland.