



Technology Requirements for Cold and Tropical Wind-Diesel Applications

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Wind-Diesel Technology Needs

- **Low maintenance**
- **High reliability**
- **Diesel grid friendly**
- **High power quality**
- **Simplified installation**
- **Serviceability**
- **Remote monitoring/diagnostics**
- **Efficiency in all wind conditions**
- **Low noise operation**



Cold Weather Requirements

- Cold weather operation: -40 C
- Cold weather servicing
- Icing resistance/icing protection
- Self protection from cold soak events



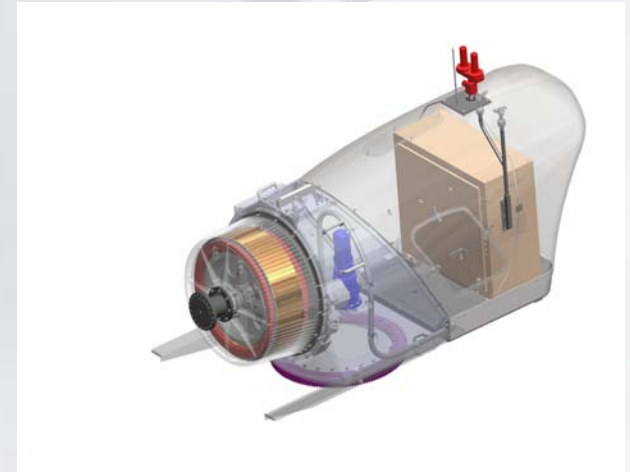
Tropical Requirements

- Storm readiness
 - Secure rotor, stabilize tower, tilt-down, etc
- Corrosion resistance



Northwind[®] 100 Turbine Design

- Direct-drive (gearless) architecture
- Variable speed operation
- Permanent magnet generator
- Fixed pitch rotor (stall control)
- Upwind orientation
- Integrated Power Electronics
- Tubular Monopole Tower



Direct.

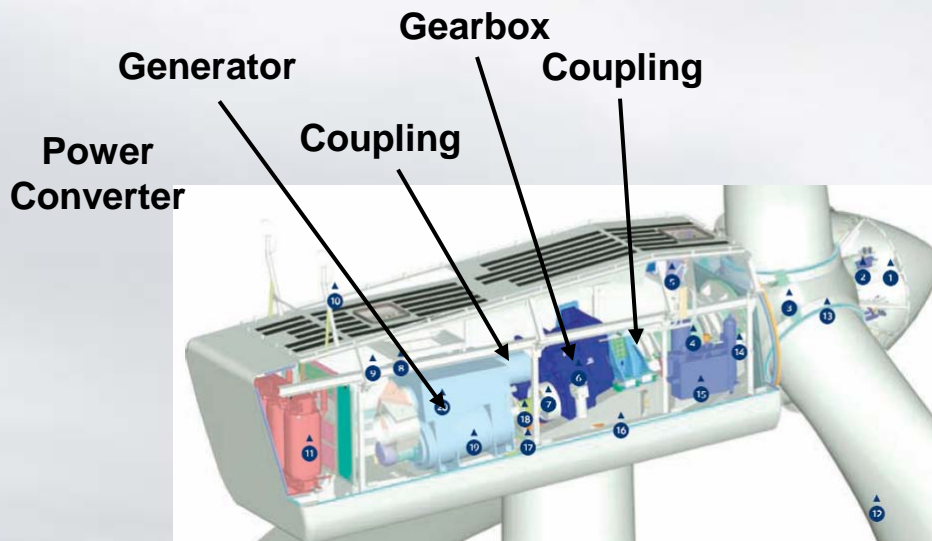
Northwind[®] 100 Specifications

- 100 kW rated output
- 21 and 19 meter rotors
 - IEC Class II and I
- 37 and 30 meter towers
- 480V, 3-Phase output
- VAR Support (+/- 45 kVAR)
- Cut-in: 3.5 m/s
- Temperature: -20°C to 55°C
 - -40C for Arctic model

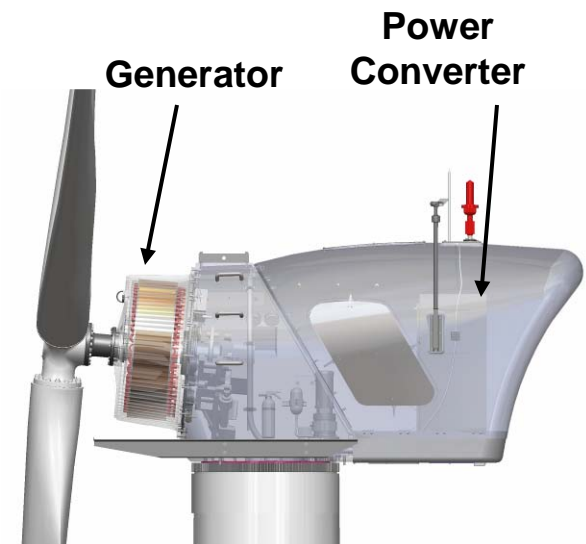


Direct Drive – Efficiency & Simplicity

- Higher Energy Capture + Lower O&M Costs = Reduced COE
- Fewer moving parts for high reliability
- Better grid support and power quality



Geared Drivetrain



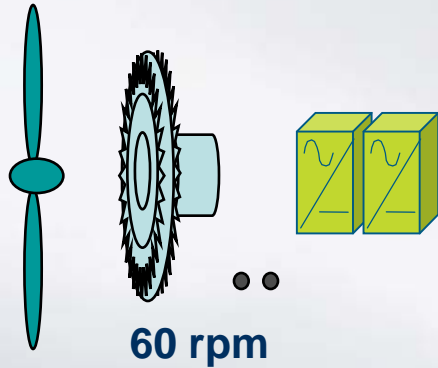
Direct Drive



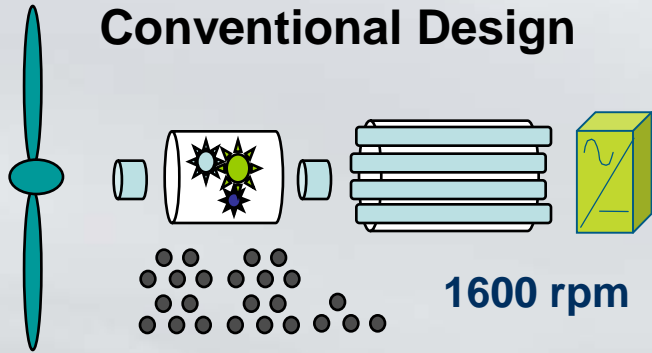
Direct.

Less is More

Direct Drive



Conventional Design



Rotating Mechanical Elements in Drivetrain	Bearings in Drivetrain	Hydraulic Subsystems
1	2	0
12	24	2

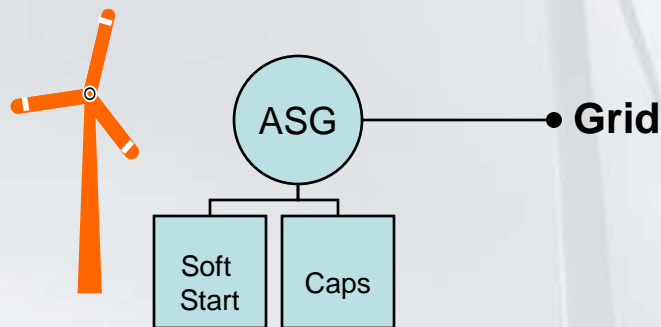


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Induction Generators vs. Converter-Controlled Interconnect

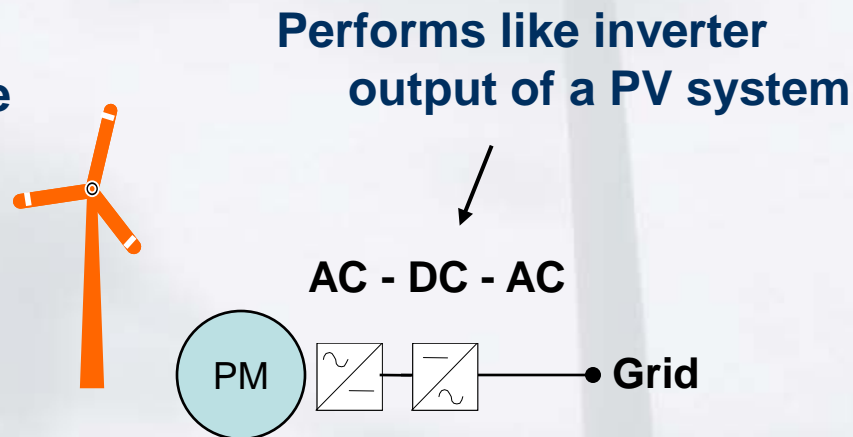
Asynchronous Induction Turbine (ASG)

- Inrush current
- Stepped power factor control
- Power factor capacitor switching transients



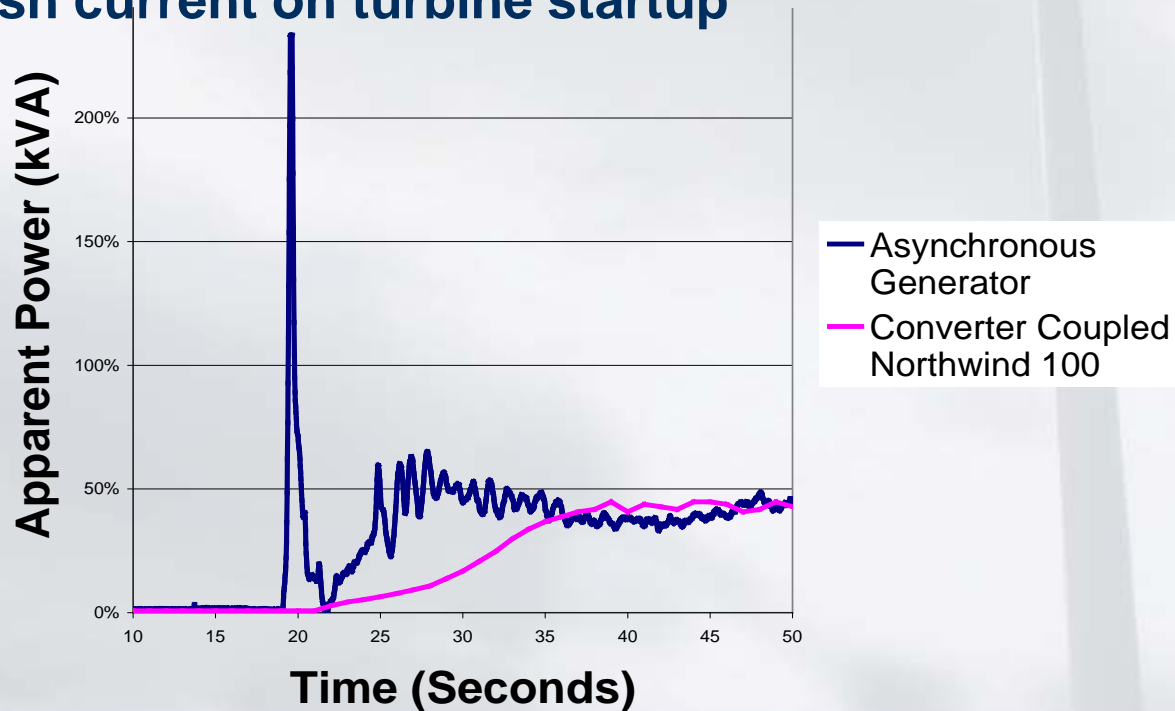
PMSG Full Power Converter Turbine

- 'Wild' AC to DC to regulated AC
- PF control *with or without* turbine in operation +/- 45kVAR



Power Quality Benefits of a Power Converter Connected Turbine vs. Induction Turbine

- Reactive power control (Northwind 100 is +/- 45kVAR with or without wind) can be used to actively support grid voltage
- No inrush current on turbine startup



U.S. Department of Energy “Distributed Wind Turbine” Program



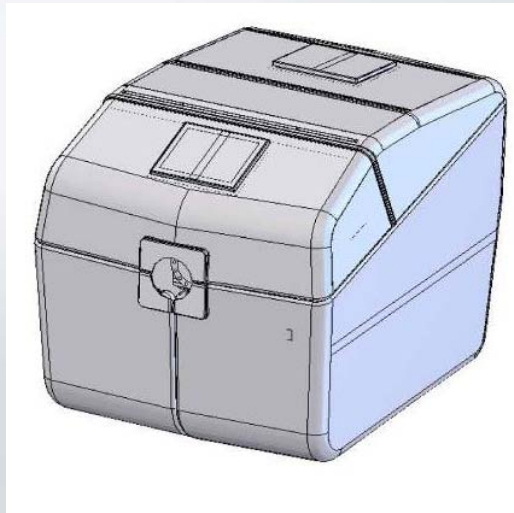
Design Targets:

1. Increased energy capture
2. Improved reliability
3. Reduced cost
4. Exponential increase in viable sites

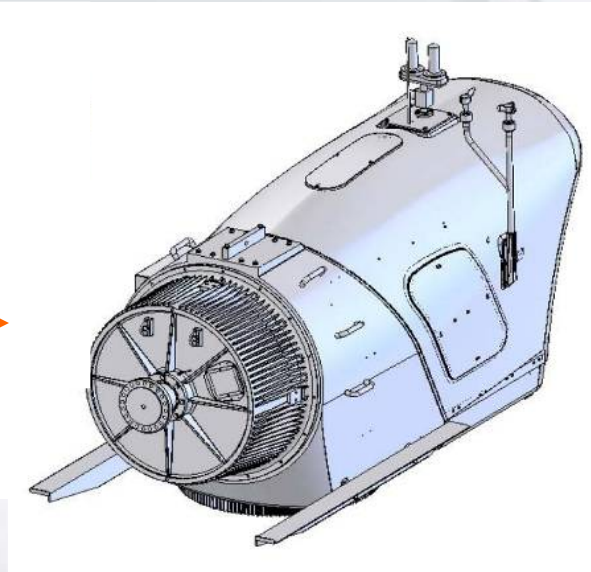


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Evolution of the Northwind® 100 Turbine



Direct Drive with
Wound Rotor
Generator

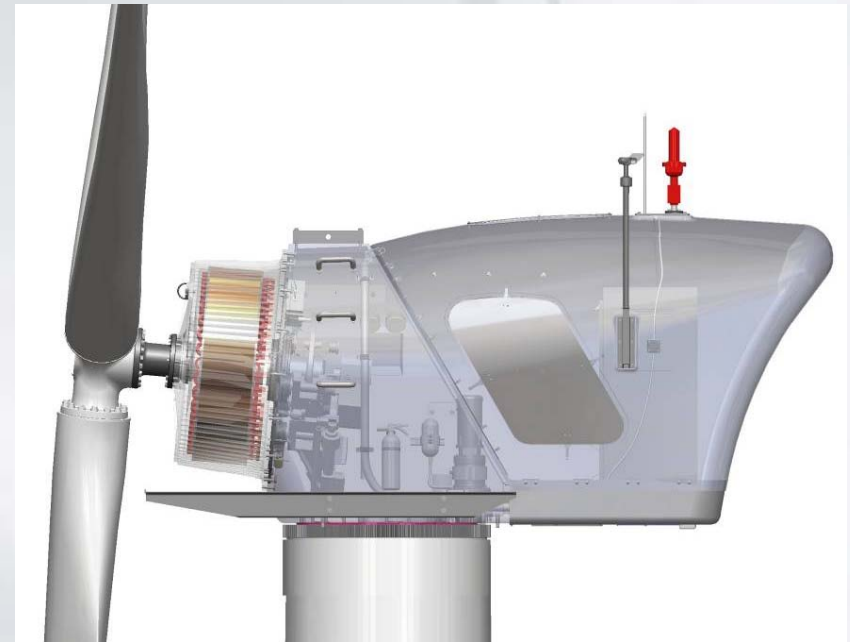
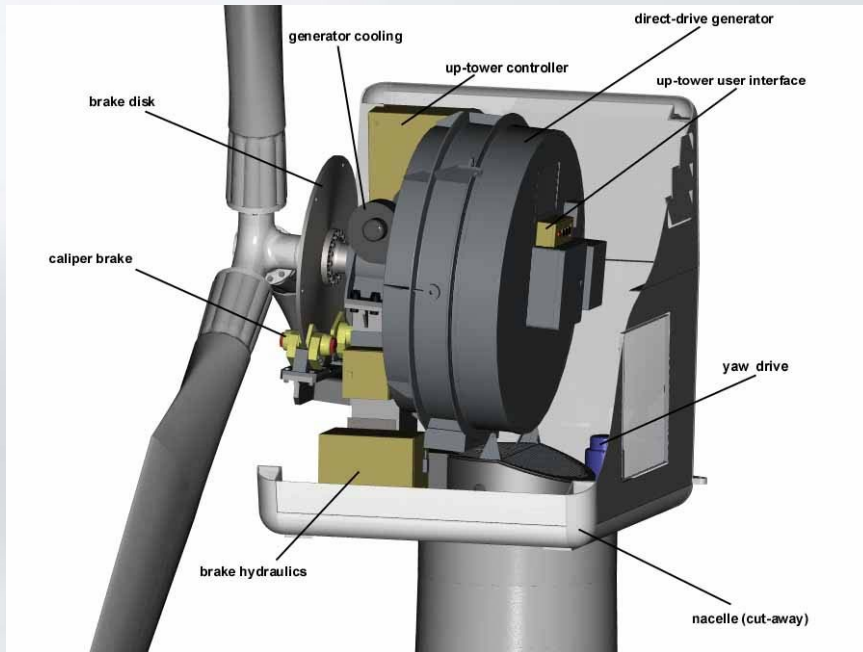


Direct Drive with
Permanent Magnet
Generator



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Northwind 100 Product Improvement



Wound Rotor



Permanent Magnet



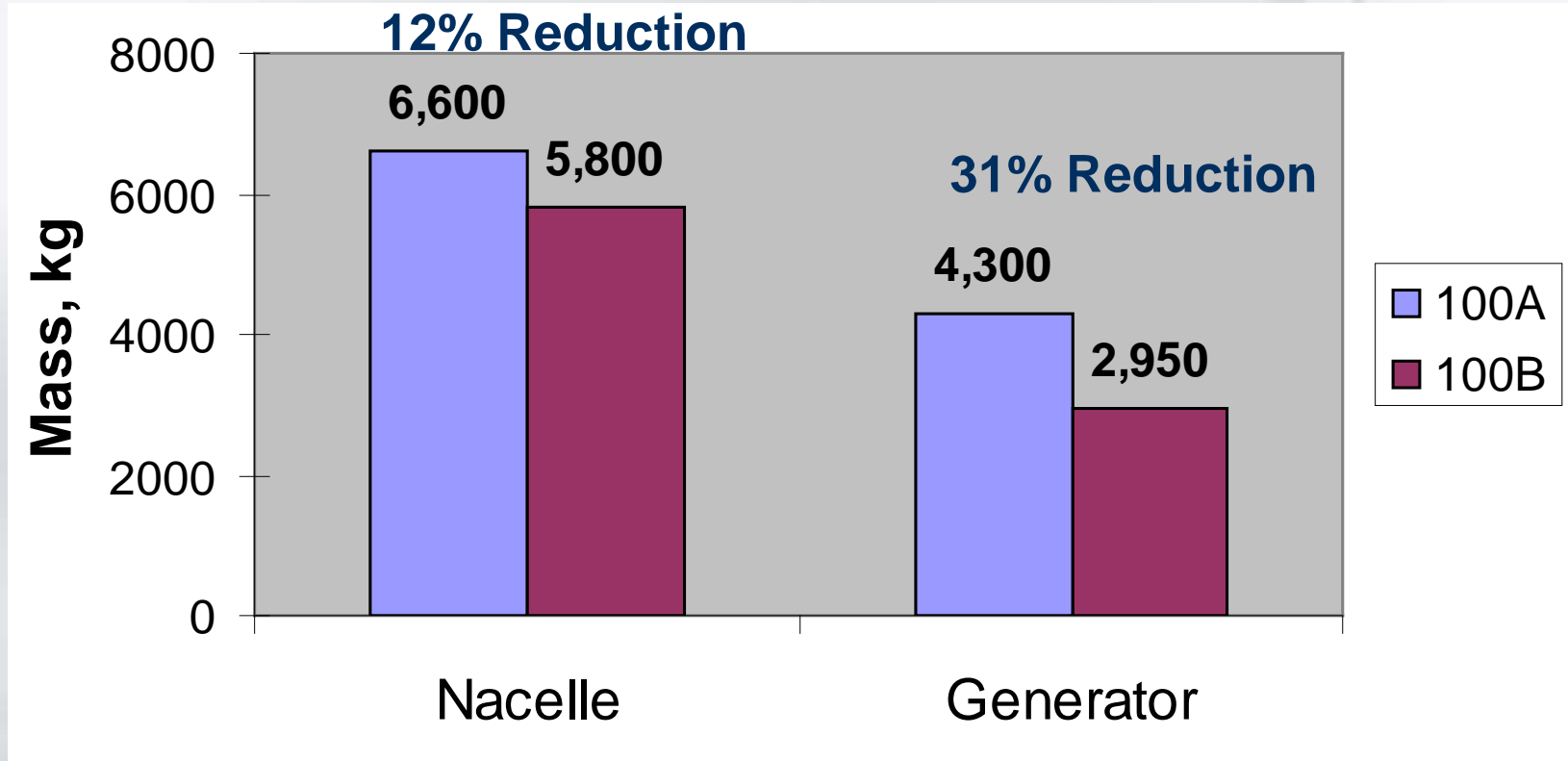
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Wound Rotor vs. Permanent Magnet



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Reduced Weight = Lower Cost



Taller “Soft” Tower

	100A	100B	% Change
Tower Height	30m	37m	+23%
Tower Weight	13,800kg	13,100kg	-5%



- Three section nested design simplifies shipping: single 40' flatbed truck
- Installation with a common 60-ton truck crane

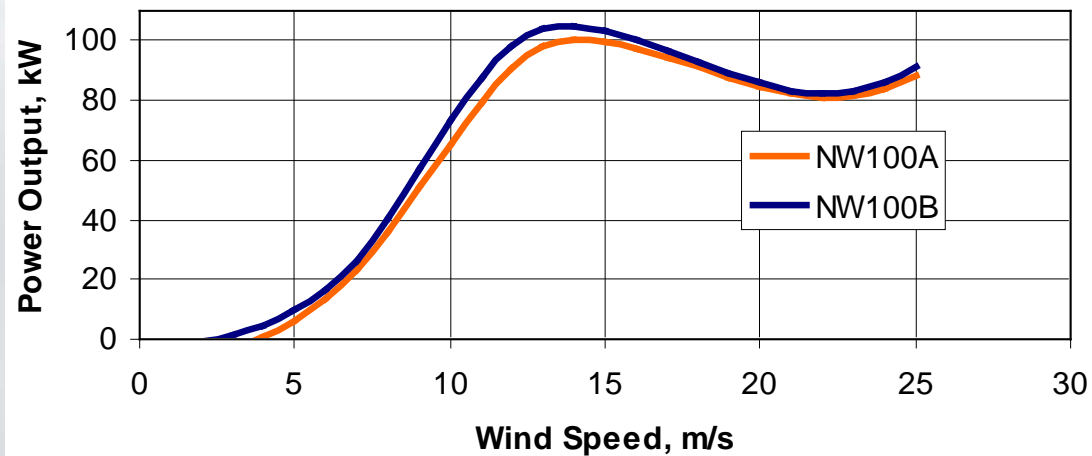


Purpose Designed Rotor: Better Performance in Low Wind Speeds *and* Lower Noise



- Soft stall characteristics
- Low noise design <55 dBA at 40m
- 16% to 20% higher annual energy at sites with 4–7 m/s

Northwind 100 Power Curve
Standard Density



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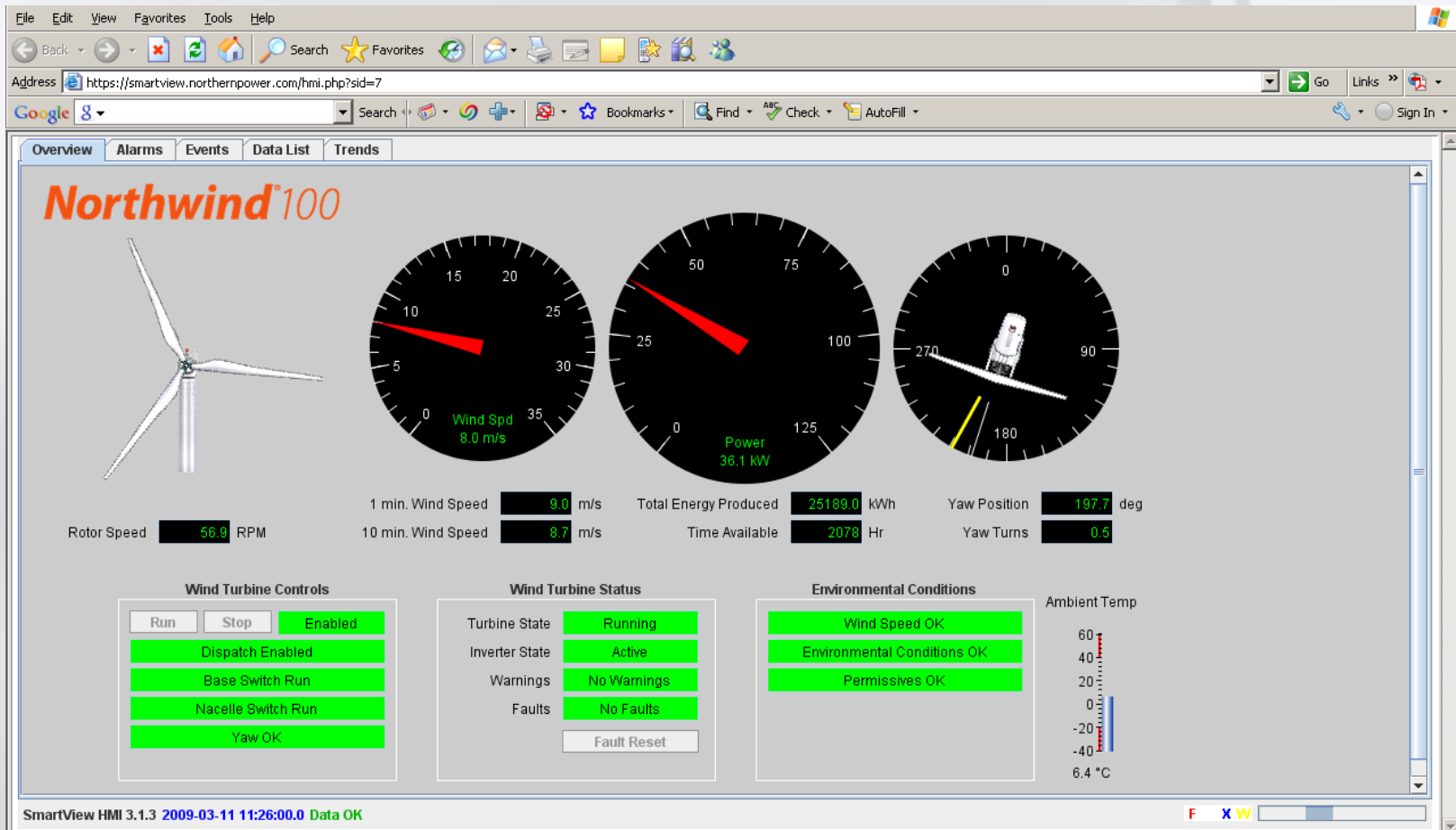
Low O&M as a Priority

- 1-year service interval
- No slip rings
- No hydraulics
- Fewer parts
- Automated lubrication for main shaft
- SmartView[®] remote monitoring



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SmartView SCADA Monitoring System



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Northwind 100 Arctic



- Operation down to -40C
 - Low temperature steel alloys for structural components
 - Low temperature rated electronics where possible
 - Environmental controls with heaters to protect sensitive components
- Black hydrophobic polymer blade coating
 - Ice resistant for less icing events
 - Accelerates ice shedding after icing event
 - Hardened surface for long life
- Class S Operation
 - Safety factors based on higher air density: 1.34 kg/m³ vs. 1.23 kg/m³ for IEC Class II rating
 - Changes extreme wind rating: 56 m/s vs. 59.5 m/s for IEC Class II



Thank You

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