Blade Needs for New Generation of Wind Turbines

Jonathan Lynch
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Company Profile

Gearless, PM Generator Wind Turbine Manufacturer

NP 100
- 100 kW direct drive turbine for community, net-metering and village power applications
- Manufacturing in 100,000 ft² Barre, VT facility
- Selling to North American and EU markets

NP 2.2 MW
- 2.2 MW PM, direct drive turbine
- High energy capture
- Low O&M costs
- Prototype installations in 2010
Northern Power Overview

“Old Northern”

- 30+ year wind turbine experience; 400 systems installed globally
- Strong expertise & IP in PM generator & power electronics
- Expertise in wide range of turbine sizes (3KW- MW)
- Company involved in wide variety of distributed energy and remote power activities

(Precambrian to 2008)

“New Northern”

- Acquired in 2008 by private investors
  - Create focused wind turbine company
  - Commercialize next-generation technology
- Heavy investment underway
  - World-class manufacturing & quality systems
  - New management
  - Doubled workforce to 170
  - Manufacturing in Vermont USA
  - Offices in Vermont, Boston & Zurich

- Focus on Permanent Magnet-Direct Drive (PMDD) turbines
- Leader in Community Wind with NP 100
- Launching NP 2.2 for Utility-Scale marketplace
  - Prototype turbines 2010
  - Pilot series 2011
Northern Power’s Key Technology Differentiators …

Direct Drive
- Direct drive advantages without cost or weight penalty
- Higher reliability
- Low turbine cost
- Better low-wind production
- Lower maintenance costs
- Superior power quality
- Quieter operation

Permanent Magnet Generator

FlexPhase™ Power Converter

Lower Cost of Energy
## Northern Power Turbine Specifications

<table>
<thead>
<tr>
<th>Model</th>
<th>NP 100</th>
<th>NP 2.2/93</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Class</td>
<td>IEC WTGS IIA(^1)</td>
<td>IEC WTGS IIA(^1)</td>
</tr>
<tr>
<td>Power Regulation</td>
<td>Variable speed; aerodynamic stall</td>
<td>Variable speed; pitch control</td>
</tr>
<tr>
<td>Rotor Diameter</td>
<td>21 meters</td>
<td>93 meters</td>
</tr>
<tr>
<td>Rated Electrical Power</td>
<td>100kW</td>
<td>2200 kW</td>
</tr>
<tr>
<td>Hub Height</td>
<td>30, 37 meters</td>
<td>80, 100 meters</td>
</tr>
<tr>
<td>Generator Type</td>
<td>Synchronous permanent magnet</td>
<td>Synchronous permanent magnet</td>
</tr>
<tr>
<td>Converter Type</td>
<td>Full rated power converter</td>
<td>Full rated power converter</td>
</tr>
<tr>
<td>Yaw System</td>
<td>Electromechanical yaw drive Friction brakes</td>
<td>Electromechanical yaw drives (6) Caliper brakes</td>
</tr>
<tr>
<td>Pitch System</td>
<td>None</td>
<td>Electromechanical pitch drives</td>
</tr>
<tr>
<td>System Controller Type</td>
<td>NP SCB integrated control system</td>
<td>Industrial distributed control system</td>
</tr>
<tr>
<td>Monitoring System</td>
<td>NP SmartView(^\circ)</td>
<td>NP SmartView(^\circ) or customer specified</td>
</tr>
</tbody>
</table>

\(^1\) For IEC WTGS IIA certification, the machine must be operated at rated voltage for the maximum power specified.
NP 100 System Architecture

- Blade
- PM Generator
- Rotor Hub
- Mechanical Brake (behind generator)
- Optional FAA Light
- Nacelle Cover
- Power Converter & System Controller
- Mainframe
- Yaw Assembly (below Mainframe)
- Service Platform
- Meteorological Instruments
- Tower
NP 100 Applications in Remote Sites…
...and in the Built Environment
**NP 2.2/93 Overview**

- Three bladed, upwind pitch controlled rotor
- Electro-mechanical pitch actuation with AC drives
- Gearless, direct drive architecture
- Liquid cooled permanent magnet generator
- Full power conversion
- Compliance with latest grid standards
- Safety system: individual pitch with energy storage
- Driven yaw & active friction system
Current Blade Position

- **NP 100**
  - 10m blade designed for variable speed stall control
  - NP owns blade design
  - Manufactured by multiple third party suppliers

- **NP 2.2/93**
  - 45.3m blade designed for variable speed pitch control
  - Using third party design available on the market
    - Risk mitigation while development focus is on drive train validation
    - Blade certification in place
    - Investigation of production options underway
  - Using blade load sensing system
    - Initially used for data collection and loads validation
    - Configured to allow use for rotor IPC
Blades for Direct Drive Wind Turbines

- Blade design very similar for geared and gearless turbines, but some possible differences in optimization
- Optimizing rotor design for PMDD architecture:
  - High partial load drive train efficiency
  - Direct drive generator torque and mass inversely related to rotor rated speed
  - Higher tip speed >> higher rotor speed >> decreased generator cost and weight
  - >> Design for highest achievable tip speeds while still controlling blade acoustics
- In some cases, a slightly smaller, faster rotor may yield optimum COE for gearless turbines as compared to geared turbine designs
- Integrate blade inboard root section design with large direct drive generator form for increased energy capture
What we need from the blade industry

- More OEMs with standard and proven blade designs on the market; turbine suppliers need more options as they do make-buy analysis

- Decreased risk for introduction of new blade designs
  - Industry history of systemic blade issues needing field remediation
  - This backdrop affects our blade strategy
  - Market is sensitive to blade risk for emerging turbine suppliers, wants minimal exposure to new blade designs because of perceived (and real) risk
Blade Risk Reduction

- Risk reduction areas
  - Blade designs that use damage tolerant, robust structures
  - Continued improvement in manufacturing process control
  - Blade design validation testing that really finds issues
    - More/better blade subsystem and component testing
  - Blade condition monitoring
    - Long term monitoring of blades; damage accumulation, condition and life prediction
Other Observations & Suggestions

- US blade manufacturers have largely been build-to-print suppliers
  - need tighter integration with domestic and global design centers to bring new rotor developments to market while managing risk
  - Add more internal aero and structural expertise
  - Leverage manufacturing process control from other industries

- Work with industry to identify “standard” blade models that can be used by multiple turbine manufactures
  - Reduced investment risk, better mold utilization
  - Design blade so variants can be produced with minimal expense to meet turbine supplier needs

- Offer integrated blade package complete with condition monitoring system to track full life cycle; “a blade with a history”

- Build capabilities and partnerships to support industry trends going forward
  - Advanced materials development
  - Sectional blades for large onshore and offshore markets
  - Smart blades with complete sensor systems
Thank you

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NP 100

NP 2.2 MW