Sandia’s
Wind Energy Program
Overview

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The State of the U.S. Wind Industry

- **Growth in U.S. robust**
  - 45% increase of installed MW in 2007 (5,240 MW)
  - U.S. could become the world leader of total installed capacity by 2009

- **Boom and busts cycles**
  - PTC extensions and expirations

- **Installed costs are increasing**
  - Weak Dollar
  - Raw Materials (e.g., Steel, copper) are more expensive

- **2 year backlog for turbine orders**
U.S. Installed Wind Capacity
(MW as of Jan 16, 2008)

1 MW powers ~300 homes

Global Top 5
Germany 22247 7%
U.S. 16819 1%
Spain 15137 10%
India 7114 2%
Denmark 3136 20%
**Program Goals:**

- Actively support the development of 20% U.S. electrical energy produced by wind – Advanced Energy Initiative
- Secure national benefits wind provides (economic development, national security, environment)
- Substantially accelerate deployment activities

**Track Record: Investment in Wind Energy Program Delivers Results**

- Program-supported technology capturing significant market share
- DOE market transformation activities are removing barriers to deployment

Program Focus Shifting to Enable 20% Wind Generation in the United States. 20% Wind = $500 Billion Investment
Program Focus & Activities

Technology Viability:

Distributed Wind Technology
- Residential & Businesses
- Industrial & Commercial
- Community-Based Wind Power

Large Wind Technology
- Utility Scale Wind Farms
- Turbine Productivity and Reliability Enhancements
- Emerging Wind Applications

Technology Acceptance
- Wind Powering America
- Wind Siting
- Environmental Impact

Systems Integration
- Wind Integration
- Transmission
- Interconnection and operation

Technology Application:

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Wind Program Goals

1981: 40 cents/kWh

Decreasing Cost Due to:
- Increased Turbine Size
- R&D Advances
- Manufacturing improvements

NSP 107 MW Lake Benton, MN wind farm

2007: 5-8 cents/kWh with no PTC

Recent Cost Increases are due to:
- Price increases in steel & copper
- Turbines sold out for 2 years
- Exchange rate

Goal: To make wind competitive without subsidies
SNL Wind Energy Background & Accomplishments

- Established in Mid 1970’s
  - Primary focus VAWT’s
  - Industry partnerships
- Transitioned to Blades in early 1990’s
- 15 Full-Time Employees
- Several Contractors and Students

Mission:
To provide a knowledge base expertise in the design and advancements of composite wind turbine blades and turbine reliability, in order to accelerate the penetration of Wind Energy.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>SNL Wind Program Established</td>
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<tr>
<td>1977</td>
<td>17m VAWT Fabricated</td>
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<tr>
<td>1981</td>
<td>1st Wind-Turbine Specific Airfoils</td>
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<tr>
<td>1982</td>
<td>FloWind Technology Transfer</td>
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<tr>
<td>1984</td>
<td>34m VAWT Test Bed</td>
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<tr>
<td>1988</td>
<td>SNL/MSU Material Dbase Established</td>
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<tr>
<td>1994</td>
<td>SNL Blade Program Started</td>
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<tr>
<td>1998</td>
<td>Blade Manufacturing Initiative</td>
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<tr>
<td>2003</td>
<td>Incorporation of Carbon on Blades</td>
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<tr>
<td>2005</td>
<td>K&amp;C Swept Blade Contract</td>
</tr>
<tr>
<td>2006</td>
<td>Reliability Program Started</td>
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<tr>
<td>2007</td>
<td>RSI Program Started</td>
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Department R&D Areas

- **Blade Technology**
  - Materials and Manufacturing
  - Structural, Aerodynamic, and Full System Modeling
  - Sensors and Structural Health Monitoring
  - Advanced Blade Concepts
  - Lab - Field Testing and Data Acquisition

- **System Reliability**
  - Industry Data Collection
  - Improve reliability of the existing technology and future designs

- **System Integration & Outreach**
  - DOE/Wind M&O
**Program Focus**

Program Focus On Industry Needs
- Increase reliability
- Improve turbine O&M
  - Shift from scheduled maintenance to condition based maintenance
  - Redundant sensors
- Increase energy capture
  - Active aerodynamic control
  - Advanced control research (adaptive architecture)
- Improve blade design to eliminate upcoming barriers
  - Transportation (segmented blades)
  - Strategic use of advanced materials
  - Embedded sensors on blades
- Improve turbine availability
  - Structural health monitoring
- Higher fidelity modeling

Smaller turbines → Larger turbines

$ → $$$

Build, Break, Redesign → Advanced Simulation
Example: Blade Advancements Under Supporting Research & Testing

Sub-scale Blades (9 meters)

- **CX-100**
  - Carbon spar cap
  - Glass skin and shear web

- **TX-100**
  - Carbon triax in skin for passive bend-twist coupling
  - Constant spar cap thickness

- **BSDS (Blade System Design Study)**
  - Flatback airfoils
  - Carbon spar cap
  - Slenderized planform
  - Large scale architecture
  - Highly efficient structural design

First Blade Designs with Carbon Fiber

TX-100 skin w/ off-axis carbon fiber
Sandia’s Reliability Program

Failure and repair data
Replacement data
Performance data
Power/loads

National Reliability Database

SNL performs Analysis and Assessments

R&D efforts to improve product design and manufacturing resulting in increased reliability

Turbine manufacturers and component suppliers

Reporting

Failure rates – what components cause the greatest downtime? What repairs cost the most?

SNL performs Analysis and Assessments
Sandia Customers & Partnerships

- **Current Customers**
  - Texas Tech (DAS & Field Testing)
  - 3TEX (Materials & Field testing)
  - Aither (Sensors)
  - NASA (Sensors)
  - Acellent (Sensors)
  - Owens Corning (Materials)
  - Clipper Wind (Manufacturer)
  - Vestas Wind (Manufacturer)

- **Past Partnership Success: Example of TPI Composites**
  - Historic supplier of 100kW blades
  - Was out of the wind business
  - Now:
    - TPI and Mitsubishi have a joint venture – Vienteck in Juarez, Mexico
    - Manufacturing blades for 1-2 MW Mitsubishi machines
    - 40m long blade now being tested
    - TPI patented SCRIMP® technology
    - Now a leader in AWEA support for the program
Summary

- SNL Primary Research Focus is on Blades & System Reliability
  - Efforts Underway to Reduce Blade Weight Growth for Larger Blades
    - Hybrid composite subscale blades have been manufactured
    - Development of structurally efficient airfoils
    - Advanced research has enabled weight reductions of 66% - 750lb -> 250lb

- Engaged in Increased Reliability Efforts
  - Developing strategic partnerships with industry
  - Improvements in O&M

- Establishing Relationships with Outside Groups to Increase Capability and Improve Response Time

- SNL is supporting the effort of the 20% Action Plan
“...we could generate up to 20% of our electricity needs through wind...”

President George W. Bush - February 21, 2006

Thank You