Sandia's Wind Energy Program Overview

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NNSA National Nuclear Security Administration

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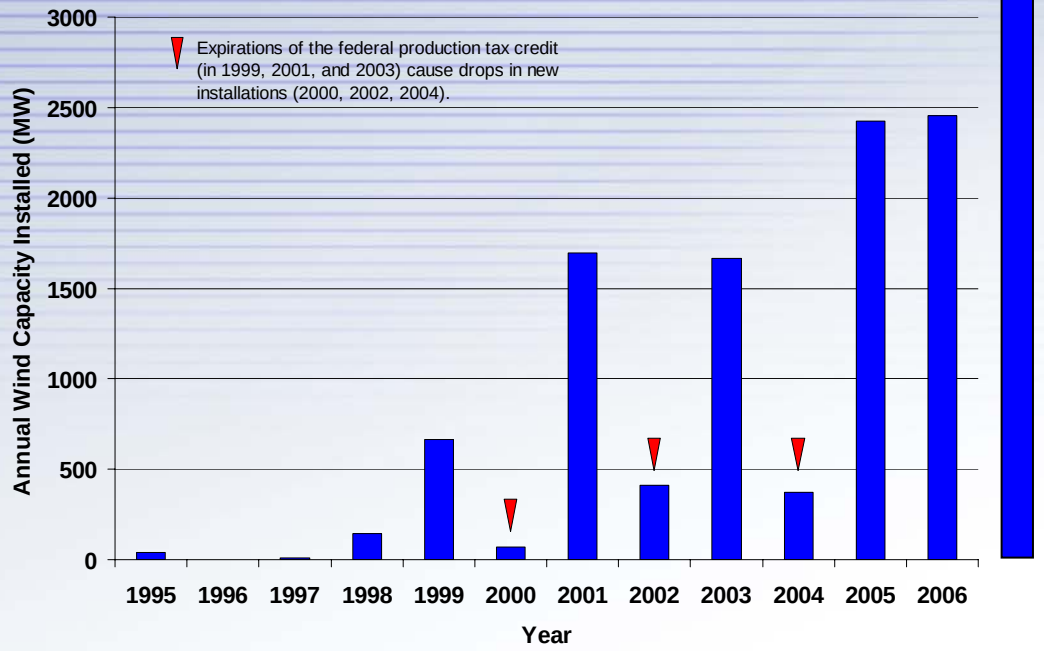
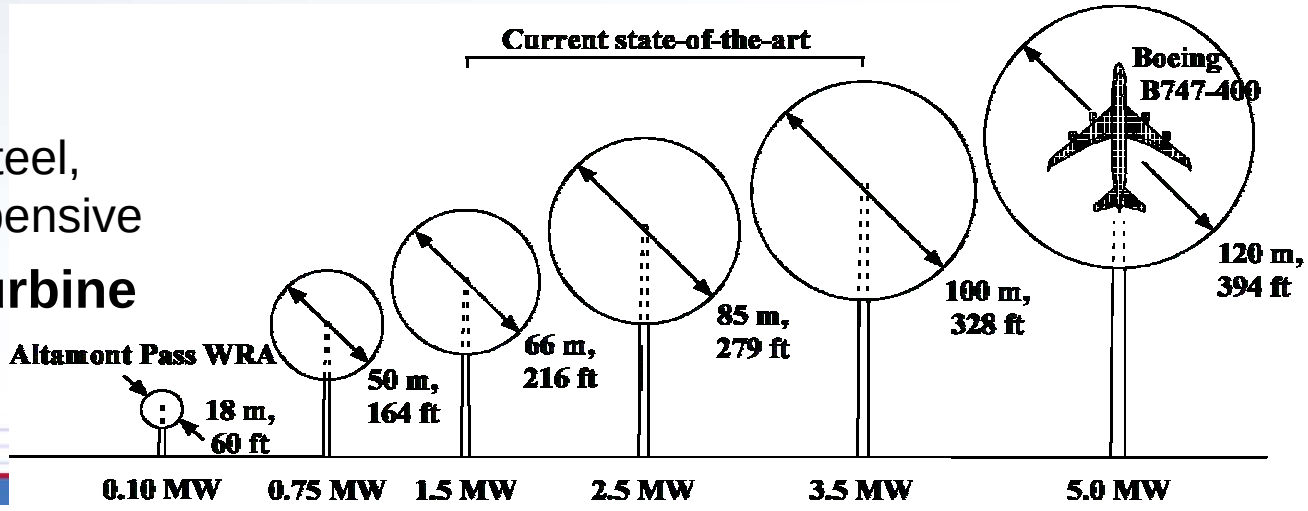
The State of the U.S. Wind Industry

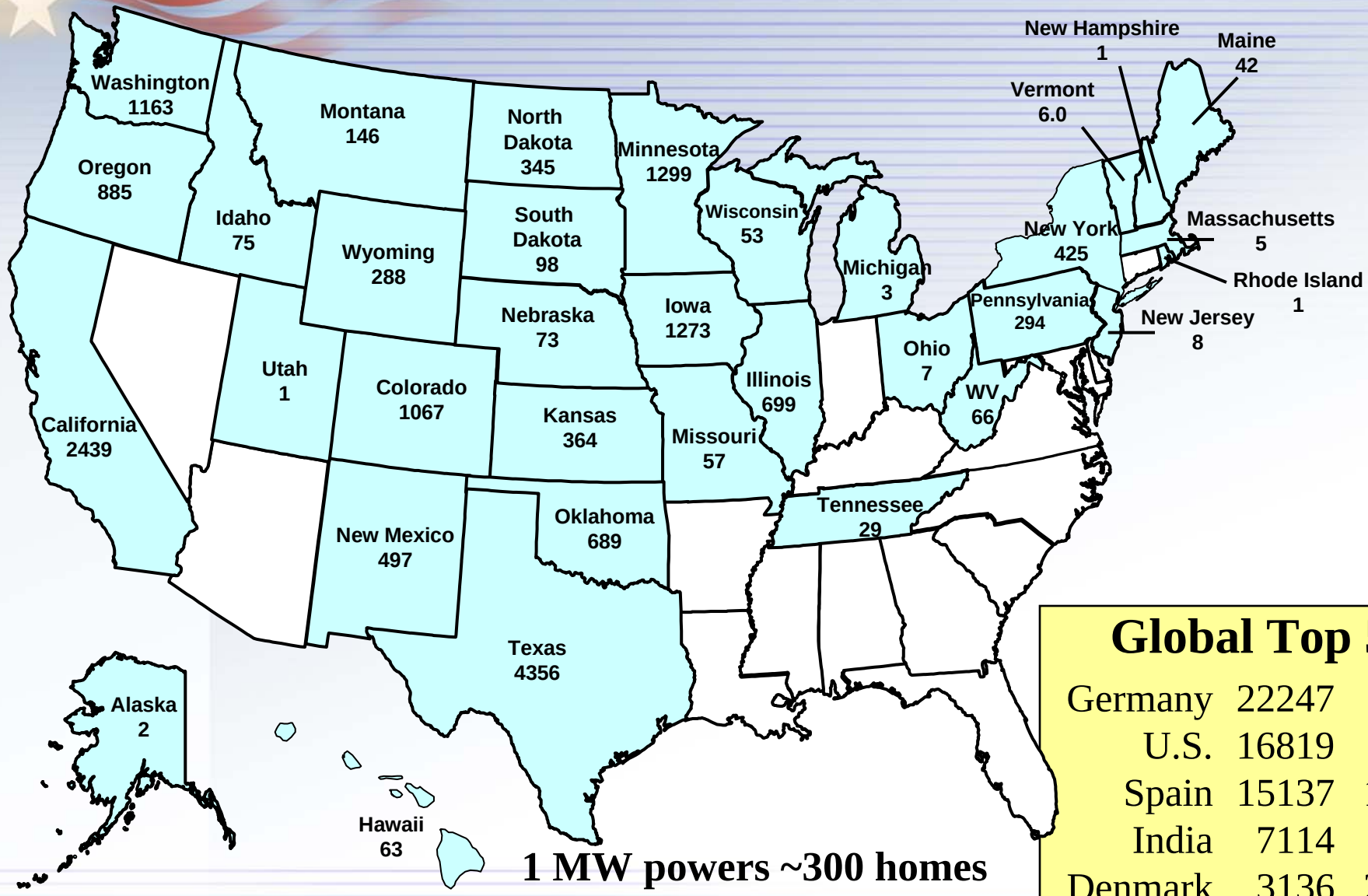
- **Growth in U.S. robust**
  - 45% increase of installed MW in 2007 (5,240 MW)
  - U.S. could become the world leader of total installed capacity by 2009
- **Boom and busts cycles**
  - PTC extensions and expirations
- **Installed costs are increasing**
  - Weak Dollar
  - Raw Materials (eg. Steel, 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%

sources: awea.org, Wind Power Monthly, windpowerindia.com, ewea.org

DOE's Wind Energy Program

Program Goals:

- Actively support the development of 20% U.S. electrical energy produced by wind – Advanced Energy Initiative
- Develop domestic energy options– Energy Policy Act of 2005
- 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 Application:

Technology Acceptance

- Wind Powering America
- Wind Siting
- Environmental Impact

Systems Integration

- Wind Integration
- Transmission
- Interconnection and operation

Technology Viability:

Large Wind Technology

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

Distributed Wind Technology

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

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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

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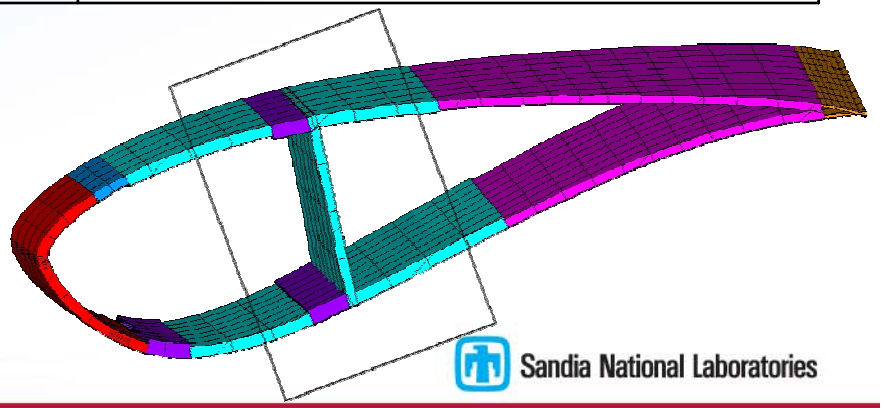
SNL Wind Energy Background & Accomplishments

- **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**

1975	SNL Wind Program Established
1977	17m VAWT Fabricated
1981	1st Wind-Turbine Specific Airfoils
1982	FloWind Technology Transfer
1984	34m VAWT Test Bed
1988	SNL/MSU Material Dbase Established
1994	SNL Blade Program Started
1998	Blade Manufacturing Initiative
2003	Incorporation of Carbon on Blades
2005	K&C Swept Blade Contract
2006	Reliability Program Started
2007	RSI Program Started

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.



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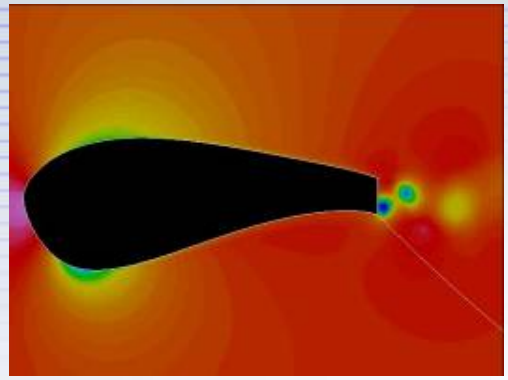
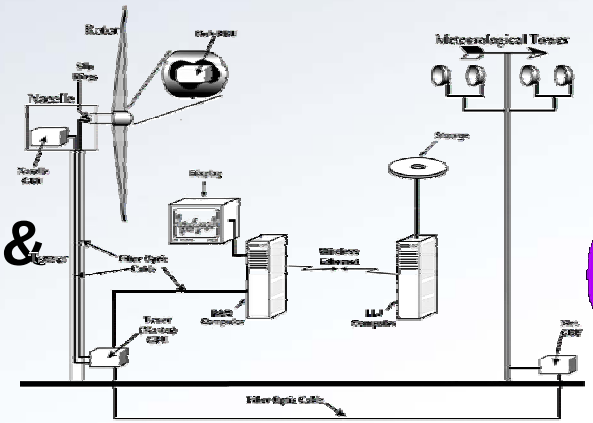
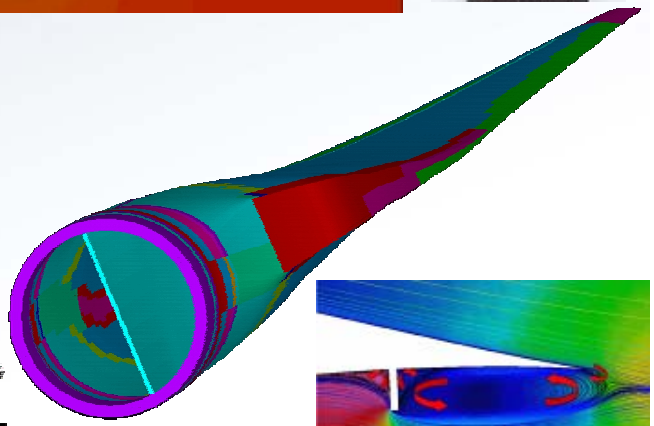
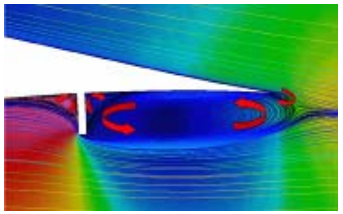
Department R&D Areas

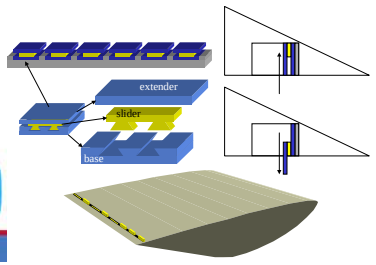
- **Blade Technology**
  - Materials and Manufacturing
  - Structural, Aerodynamic, and Full System Modeling
  - Sensors and Structural Health Monitoring
  - Advanced Blade Concepts
  - Lab - Field Testing and Data Acquisition
- **System Reliability**
  - Industry Data Collection
  - Improve reliability of the existing technology and future designs
- **System Integration & Outreach**
  - DOE/Wind M&O





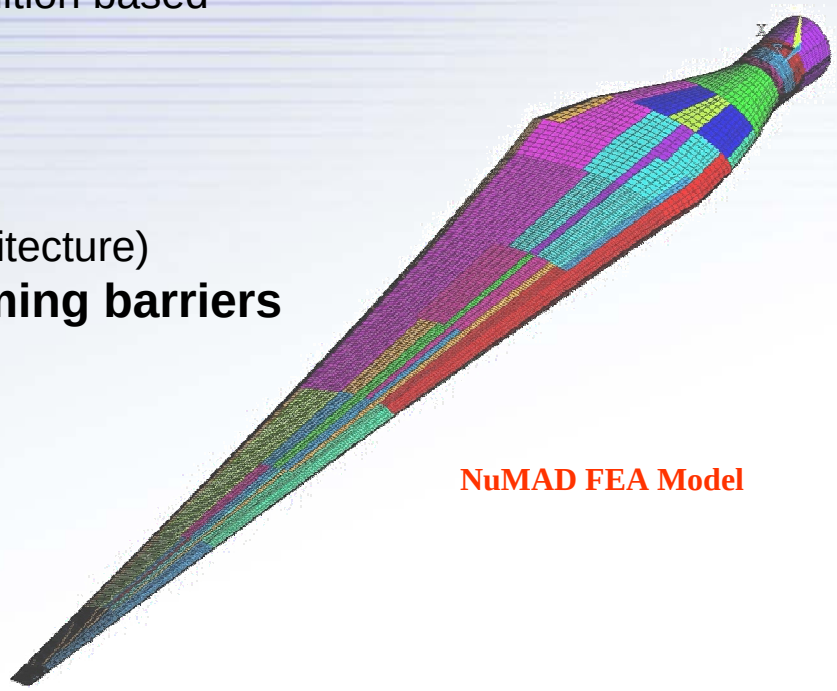






Program Focus

- **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**



NuMAD FEA Model

Smaller turbines → Larger turbines

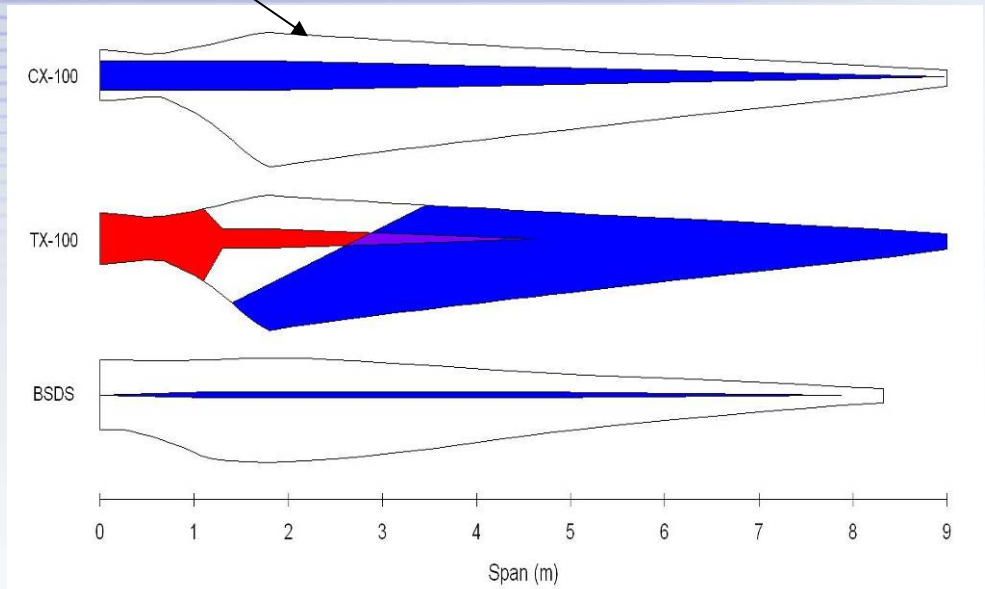
$ → $$$

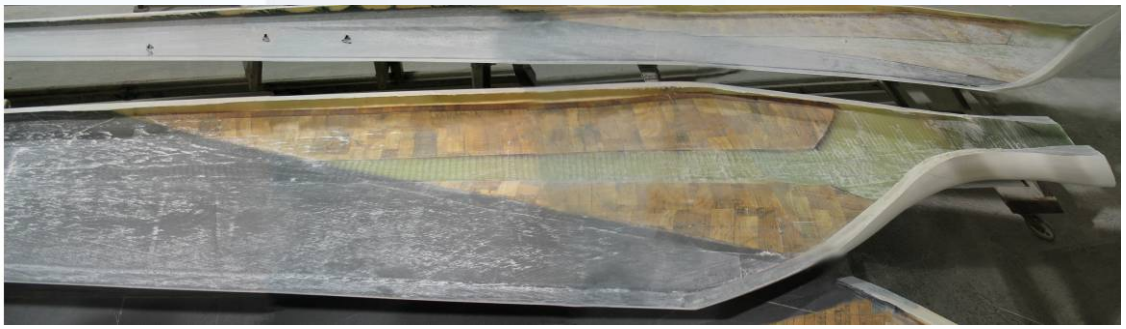
Build, Break, Redesign → Advanced Simulation

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

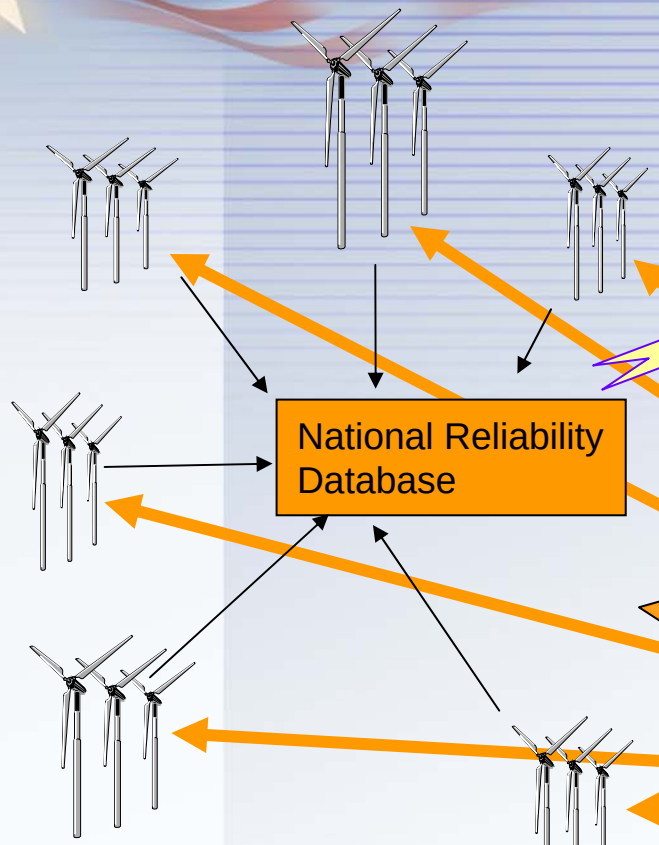
First Blade Designs with Carbon Fiber





TX-100 skin w/ off-axis carbon fiber

Sandia's Reliability Program

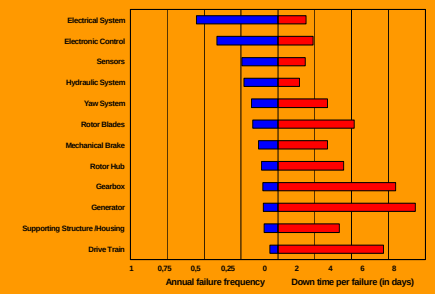


SNL performs Analysis and Assessments

National Reliability Database

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

Reporting



Failure and repair data
Replacement data
Performance data
Power/loads

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

Turbine manufacturers and component suppliers

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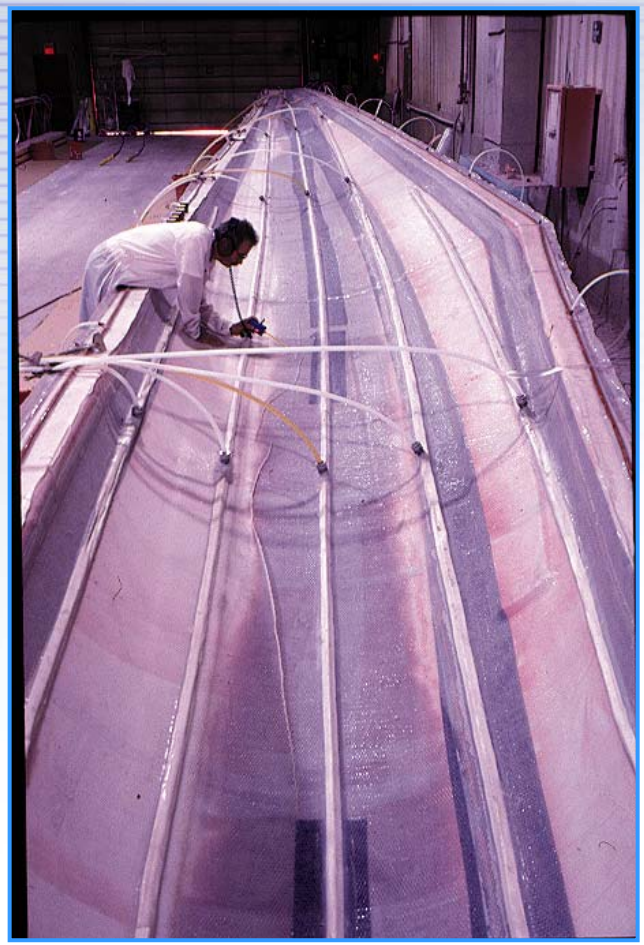
Sandia Customers & Partnerships

- **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

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