Opportunities in the Wind Industry Supply Chain – A National Perspective

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Ports-to-Plains Energy Summit
Denver, CO

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American Wind Energy Association
What is AWEA?

- American Wind Energy Association
  - www.awea.org
- National trade association for the wind energy industry
  - Legislative / Lobbying
  - Education & Outreach
  - Member Services
- Currently >2500 business, utility, academic, and non-profit members
Status of the Wind Energy Industry
Wind Energy Industry Status at End of 2010

- The U.S. wind energy industry installed 5,115 MW in 2010.
- The fourth quarter of 2010 saw 3,195 MW installed.
- Capacity nationwide now totals 40,180 MW, an increase in capacity of 15% over the start of 2010.
- Over 5,600 MW are under construction entering 2011.
- Over 400 manufacturing facilities in U.S., producing 50% of turbine components.
The wind industry installed 5,116 MW in the U.S. in 2010.

15 percent growth in 2010.

Total U.S. wind installations stand at 40,181 MW.

Average annual growth for the past five years was 35%.

U.S. wind installations represent over 21% of global wind capacity.

New wind capacity represented 26% of all new capacity installed in 2010.

Wind remained the second largest source of new installed capacity, second to natural gas at 40%.

All renewable capacity combined represented nearly 33%.

Over the past 4 years combined, wind represented 35% of all new generating capacity installed.

Operating Wind Projects, by State

Texas, the leading wind power state in America for several years running, achieved a major milestone by surging past the 10,000-MW mark for total installations, with the addition of 680 MW in 2010.

Texas achieved the mark thanks to aggressive pursuit of renewable energy and a renewable electricity standard passed in 1999 and strengthened in 2005. On average, wind now generates 7.8% of the electricity in the Electric Reliability Council of Texas (ERCOT), peaking as high as 25%. Other states active in pursuing targets for renewable energy last year were Illinois (498 MW added), California (455 MW), South Dakota (396), and Minnesota (396 MW).

Five more states doubled or more than doubled their wind power capacity in 2010. Delaware and Maryland both added their first utility-scale wind turbines in 2010. 38 states now have utility-scale wind projects, and 14 of those have now installed more than 1,000 MW of wind power.
U.S. Wind Power Capacity Installations by State in 2010 (MW)

- 38 states have utility-scale wind installations.
- 14 states have more than 1,000 MW installed.
- Top states for new installations in 2010 were Texas, Illinois, California, South Dakota and Minnesota, all installing 400 to 700 MW.

U.S. Wind Percentage of Electricity Generation by State in 2010

IA: 15%
ND: 12%
MN: 10%
SD: 8%
KS: 7%

In state with largest wind installation (TX: 10,085 MW), ERCOT received 7.8% of electricity from wind in 2010.

AWEA Priorities for 2011

- Long term PTC Extension
- Wildlife / Siting issues
- Transmission policies and legislation
- State / Regional issues
- Renewable Energy Standard at federal level
Lack of Stable Market Signals Creates a Boom-Bust Cycle for Wind
Federal RES Would Yield Significant Job Creation

Growth in Renewable Electricity Supported Jobs: 2009-2025\(^1,2\)

- 191,000 more Jobs from a 20% target in 2020
- 67,000 more Jobs from a 12% target in 2014
- 274,000 more Jobs from a 25% target.

1. Data included direct, indirect, and induced labor.
2. Results are for a 25% RES by 2025 compared to no national RES.
3. 1 Job is defined as 1 Full Time Equivalent (FTE).

Source: Navigant Consulting
37 Other Nations Have Enacted Long-Term Renewable Policy
Fossil Fuels Enjoy Permanent Incentives 5x Those of Renewables
Wind is an Affordable Form of New Energy
Wind Turbine Supply Chain – Overview
Wind Turbine Size

- **Hull Wind I**
  - Vestas V-47
  - 660 kW
  - Rotor Dia.: 47 m
  - Tower Hgt.: 50 m
- **Hull Wind II**
  - Vestas V-80
  - 1.8 MW
  - Rotor Dia.: 24.4 m
  - Tower Hgt.: 30 m
- **Mt. Tom**
  - 250 kW
  - Rotor Dia.: 14 m
  - Tower Hgt.: 25 m
- **Horns Rev**
  - Vestas V-80
  - 2 MW
  - Rotor Dia.: 80 m
  - Tower Hgt.: 70 m
- **Arkwlow Bay**
  - GE Wind
  - 3.6 MW
  - Rotor Dia.: 104 m
  - Tower Hgt.: 74 m
- **Brunsüttei Ger.**
  - REpower
  - 5 MW
  - Rotor Dia.: 126 m
  - Tower Hgt.: 120 m
  - Offshore

<table>
<thead>
<tr>
<th>Capacity</th>
<th>50 kW</th>
<th>250 kW</th>
<th>660 kW</th>
<th>1800 kW</th>
<th>2000 kW</th>
<th>3600 kW</th>
<th>5000 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotor Dia.</td>
<td>14 m</td>
<td>24.4 m</td>
<td>47 m</td>
<td>80 m</td>
<td>80 m</td>
<td>104 m</td>
<td>126 m</td>
</tr>
<tr>
<td>Tower Hgt.</td>
<td>25 m</td>
<td>30 m</td>
<td>50 m</td>
<td>60 m</td>
<td>70 m</td>
<td>74 m</td>
<td>120 m</td>
</tr>
</tbody>
</table>

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DISTRIBUTION OF TURBINES INSTALLED IN 2009 BY CAPACITY

» In 2010, nearly 2,900 new turbine turbines were installed bringing the total U.S. installation to over 35,600 wind turbines.

» The average size of turbines installed in 2010 was 1.77-MW, up slightly from 1.75-MW in 2009.

Basic Supply Chain

1. Raw Materials Suppliers
2. Component Suppliers
3. Major Component Suppliers
4. Turbine Manufacturers
Wind Turbine Major Components

- **Hub**
- **Nacelle**
- **Blade**
- **Tower**
Inside a Wind Turbine Nacelle

Diagram labels:
- Spinner
- Hub
- Nacelle
- Rotor Shaft
- Oil Cooler
- Gear Box
- Coupling
- Heat Exchanger
- Control Panel
- Tower
- Pitch Drive
- Bearing Bracket
- Yaw Drive
- Sound Proofing
- Main Frame
- Generator
- Bleeding
# Turbine Components

There are over 8000 components in a turbine, including:

<table>
<thead>
<tr>
<th>Towers:</th>
<th>Nacelle:</th>
<th>Foundation:</th>
<th>Other:</th>
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</thead>
<tbody>
<tr>
<td>● Towers</td>
<td>● Nacelle Cover</td>
<td>● Rebar</td>
<td>● Transformers</td>
</tr>
<tr>
<td>● Ladders</td>
<td>● Nacelle Base</td>
<td>● Concrete</td>
<td>● Bolts/Fasteners</td>
</tr>
<tr>
<td>● Lifts</td>
<td>● Heat exchanger</td>
<td>● Casings</td>
<td>● Wire</td>
</tr>
<tr>
<td></td>
<td>● Controllers</td>
<td></td>
<td>● Paints and Coatings</td>
</tr>
<tr>
<td></td>
<td>● Generator</td>
<td></td>
<td>● Lighting</td>
</tr>
<tr>
<td></td>
<td>● Power</td>
<td></td>
<td>● Lightning Protection</td>
</tr>
<tr>
<td>Rotor:</td>
<td>● Electronics</td>
<td></td>
<td>● Steel Working/Machining</td>
</tr>
<tr>
<td>● Hub</td>
<td>● Lubricants</td>
<td></td>
<td>● Communication Devices</td>
</tr>
<tr>
<td>● Nose Cone</td>
<td>● Filtration</td>
<td></td>
<td>● Control &amp; Condition Monitoring Equipment</td>
</tr>
<tr>
<td>● Blades</td>
<td>● Insulation</td>
<td></td>
<td>● Electrical Interface &amp; Electrical Connection</td>
</tr>
<tr>
<td>● - Composites</td>
<td>● Gearbox</td>
<td></td>
<td>● Batteries</td>
</tr>
<tr>
<td>● - Blade Core</td>
<td>● Pump</td>
<td></td>
<td>● Bearings</td>
</tr>
<tr>
<td>● Pitch</td>
<td>● Drivetrain</td>
<td></td>
<td>● Brakes</td>
</tr>
<tr>
<td>Mechanisms</td>
<td>● Ceramics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>● Drives</td>
<td>● Shaft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>● Brakes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>● Rotary Union</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

There are over 8000 components in a turbine, including:

- Towers
  - Towers
  - Ladders
  - Lifts

- Rotor
  - Hub
  - Nose Cone
  - Blades
  - - Composites
  - - Blade Core
  - Pitch Mechanisms
  - Drives
  - Brakes
  - Rotary Union

- Nacelle
  - Nacelle Cover
  - Nacelle Base
  - Heat exchanger
  - Controllers
  - Generator
  - Power Electronics
  - Lubricants
  - Filtration
  - Insulation
  - Gearbox
  - Pump
  - Drivetrain
  - Ceramics
  - Shaft

- Foundation
  - Rebar
  - Concrete
  - Casings

- Other
  - Transformers
  - Bolts/Fasteners
  - Wire
  - Paints and Coatings
  - Lighting
  - Lightning Protection
  - Steel Working/Machining
  - Communication Devices
  - Control & Condition Monitoring Equipment
  - Electrical Interface & Electrical Connection
  - Batteries
  - Bearings
  - Brakes
SIZES AND MATERIAL USE FOR UTILITY-SCALE TURBINES INSTALLED IN 2009

<table>
<thead>
<tr>
<th>Capacity range:</th>
<th>1-3 MW</th>
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</thead>
<tbody>
<tr>
<td>Tower height range:</td>
<td>45-105 meters</td>
</tr>
<tr>
<td>Rotor diameter range:</td>
<td>57-101 meters</td>
</tr>
<tr>
<td>Blade length range:</td>
<td>26.8-49 meters</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>% Weight</th>
<th>% Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hub</td>
<td>6.0%</td>
<td>100%</td>
</tr>
<tr>
<td>Blades</td>
<td>7.2%</td>
<td>2%</td>
</tr>
<tr>
<td>Nacelle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gearbox</td>
<td>10.1%</td>
<td>96%</td>
</tr>
<tr>
<td>Generator</td>
<td>3.4%</td>
<td>65%</td>
</tr>
<tr>
<td>Frame</td>
<td>6.6%</td>
<td>85%</td>
</tr>
<tr>
<td>Tower</td>
<td>66.7%</td>
<td>98%</td>
</tr>
</tbody>
</table>

Source: DOE 20% Wind Energy by 2030
Wind Turbine Supply Chain – Major Components
TOWERS – Market Overview

- The tower sector was the first to develop a strong domestic supply base due to logistical issues of transporting towers. Most towers installed in the US are domestically manufactured.
- Towers are typically 2/3 of the weight of 200 to 400 ton utility-scale turbines, and are almost entirely steel.
- Number of facilities in 2004: 6
- Number of facilities in 2009: 20
- Additional announced facilities: 8
TOWERS – Mfg Locations
BLADES – Market Overview

• The blade sector was the second to develop a strong domestic supply base due to logistical issues of transporting blades. Most blades installed in the US are domestically manufactured.

• Number of facilities in 2004: 4
• Number of facilities in 2009: 9
• Additional announced facilities: 3
DRIVE-TRAIN
The drive train contains multiple value-added areas.

The U.S. is still in the process of developing manufacturing capacity for drive train components.

Domestic drive train sourcing is driven by the presence of nacelle assembly facilities.

Nacelle assembly facilities:
- Number of facilities in 2004: 3 (all GE)
- Number of facilities in 2009: 8
- Additional announced facilities: 8
TURBINE ASSEMBLY – Locations

[Map showing locations of turbine assembly on the United States map, with green circles for online locations and orange circles for announced locations.]
ELECTRICAL COMPONENTS
ELECTRICAL COMPONENTS

• Types of Electrical Components:
  • Slip Rings
  • Converters
  • Transformers
  • Electrical Wire & Cable
  • Fiber Optics
  • Control Systems & Condition Monitoring
  • Cable Accessories
  • SCADA Systems
  • Lightning Protection
  • Communication Devices
  • Batteries
  • Electrical Interface and Connection
  • Switchgear
  • Grid Connection Equipment
  • Motors
ELECTRICAL – Market Overview

- For many electrical commodities – U.S. in nascent stage of developing manufacturing capacity
- High OEM Visibility and Focus
  - High impact on reliability / total cost of ownership
  - Highly specified - heavily influenced by European standards.
  - May be proprietary technology
  - Safety implications
- Driving sourcing from current overseas suppliers
- Migration is in progress
Manufacturing Facilities and Jobs
Wind Turbine Manufacturers’ Share of Total U.S. Wind Power Fleet

At the end of 2010, there were over 400 manufacturing facilities online making wind-related products.

The online facilities span 42 states.

Online & Announced Wind-Related Manufacturing Facilities in 2010

There has been a dramatic shift towards domestic manufacturing for wind turbine components

2005

~25% domestic components
~2,500 MW installed
~1,500 turbines installed

2009

~50% domestic components
~10,000 MW installed
~5,600 turbines installed

Manufacturing continued to grow in 2010, leading to a year-end total of roughly 20,000 jobs in wind-related manufacturing.

Increase in permanent operations & maintenance jobs to help run the expanding wind power fleet.

However, jobs in construction and the various service sectors that support project installation were reduced from 2009 due to the decline in new wind installations.

Overall, even with the economic headwinds, the U.S. wind industry was still able to support 75,000 direct and indirect jobs in 2010, compared with 85,000 in 2009.

Supply Chain Opportunities – Resources and Services
Manufacturing Working Group

- Recently formed task forces
  - Incentives
  - Export Promotion
  - Qualifications & Specifications
  - R&D and Commercialization

- AWEA Manufacturing Working Group open to any AWEA business member in good standing who has US-based manufacturing and is a current supplier for the industry.

- Contact AWEA for more information at: jisaacs@awea.org or tmaves@awea.org
Transportation & Logistics WG

- The mission of the TLWG is to eliminate transportation related constraints and standardize policy and procedures between states to enable the growth of the U.S. wind industry
- Seven priority issues being pursued
- The TLWG is open to any AWEA business member in good standing who is involved in the transport and logistics associated with moving, storing and delivering wind turbines and components
- Co-chaired by Vikash Patel, GE Energy Logistics and Nikhil Amin, Trinity Logistics
- Contact: Tom Maves, tmaves@awea.org
Operations & Maintenance WG

- This working group is open to any AWEA business member in good standing who is involved in the O&M aspects of the industry.
- Co-chairs recently established, currently forming Advisory Group.
- Currently prioritizing member issues and forming strategies for solutions.
- Contact: John Dunlop, jdunlop@awea.org
GLWN: Global Wind Network

- Leading Supply Chain Advisory Group
- 1500 Manufacturers and Suppliers across North America
  - Component Head-hunters for OEMs
  - Resource to Manufacturers, Service Suppliers
- Mission: Increase the Domestic Content of US Wind Turbines
- Get Connected: GIS Supply Chain Map
  www.glwn.org
Questions?

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