

OPPORTUNITIES AND CHALLENGES FOR AUTOMOBILE COMPONENT
MANUFACTURERS TO ENTER THE WIND ENERGY VALUE CHAIN

by

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December 2009

Masters project submitted in partial fulfillment of the
requirements for the Master of Environmental Management degree
in
the Nicholas School of the Environment of
Duke University

2009

Abstract

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The wind industry in the United States has been growing rapidly over the past decade, fueled by climate change concerns, financial incentives, performance improvements and a wave of investments in “green” technology. Original Equipment Manufacturers (OEMs) of wind turbines, both foreign and domestic, are expanding their production capacity to better serve the U.S. market. This growth in manufacturing is leading to constraints on the supply of some wind turbine components, presenting an opportunity for new player to enter the industry. Auto component suppliers, in particular, are interested in this potential opportunity in renewable energy as their own industry declines.

The purpose of this Masters Project has three components. First, to assess the opportunity for auto component suppliers to enter the wind energy value chain. Second, to identify the challenges and barriers that firms face as they transition into the wind industry. And, finally, to offer potential market entry strategies. This research found that there are opportunities for auto component manufacturers to begin delivering parts for wind turbines; however, they are limited by a number of factors including the capabilities and resources of firms in auto manufacturing, significant differences in production volumes between the two industries, the size and scale of wind turbine components, and policy-dependent development cycles that drive inconsistent demand for wind turbine equipment.

Approved

Dr. Lincoln Pratson

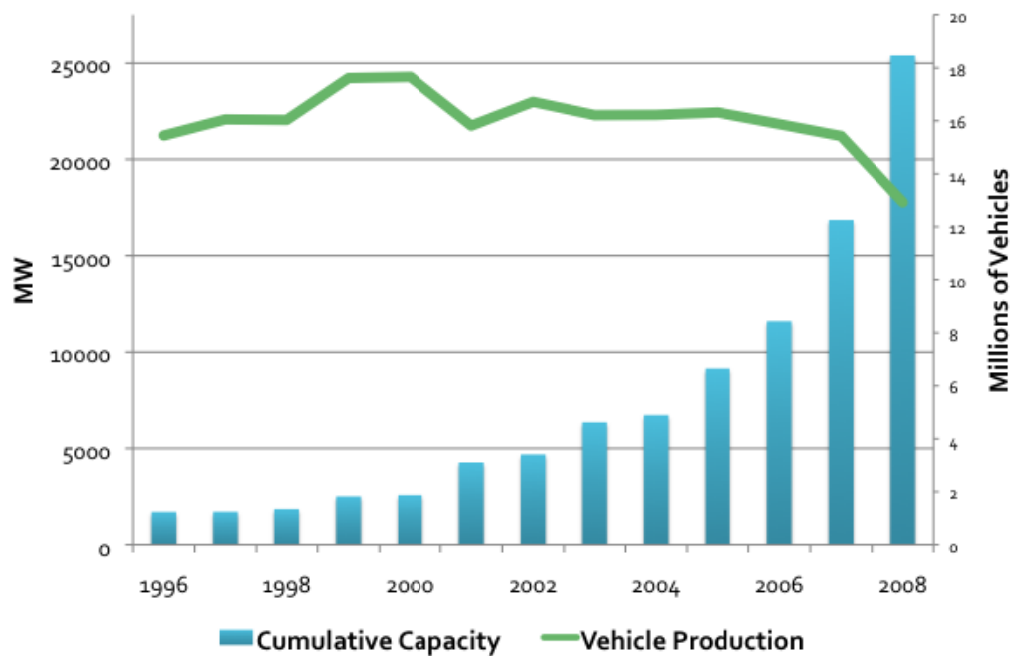
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Master's Project submitted in partial fulfillment of the requirements for the Master of Environmental Management degree in the Nicholas School of the Environment, Duke University December 2009

Introduction

The wind industry in the United States has been growing rapidly over the past decade, fueled by climate change concerns, financial incentives, performance improvements and a wave of investments in “green” technology. Figure 1 below highlights the growth in cumulative wind capacity. The U.S. Department of Energy set a goal to achieve 20 percent wind penetration by the year 2030. Meeting this goal will require the installation of approximately 100,000 wind turbines.

Figure 1:
U.S. Wind Capacity and Vehicle Production, 1996-2008¹



Original Equipment Manufacturers (OEMs) of wind turbines are expanding production capacity in order to meet growing domestic demand. Foreign manufacturers are also locating new facilities in the U.S. to better serve this market. As they build out their

¹ “Annual Wind Industry Report, Year Ending 2008.” American Wind Energy Association and “U.S. Car and Truck Sales, 1931-2008.” www.WARDSAUTO.com. Accessed on November 8, 2009.

domestic supply chains, OEMs are finding it difficult to source some components domestically and must rely on established suppliers in Europe and in some cases Asia. This creates potential opportunity for new firms to enter the wind industry and supplement the supply needs of wind OEMs.

Unlike wind, the auto industry is mature and has declined in recent years – the industry has been particularly hard hit by the current economic recession. As a result, many auto component suppliers are interested in diversifying their business by expanding into growing, high technology industries, such as renewable energy and medical devices. Many of these firms have excess capacity and may possess the capabilities and expertise needed to enter the wind industry.

However, firms in the auto manufacturing industry face several challenges as they transition their business. These include the boom/bust development cycle in wind, significant difference in the volume of manufacturing between the two industries, large size of wind turbines, and competitive pressures from established suppliers. While some firms will be able to overcome these challenges, others will find that wind is not a good fit for their business.

The purpose of the following Masters Project contains three main objectives. First, this paper aims to assess whether opportunities exist for auto component suppliers to enter the wind energy value chain. Second, this paper seeks to identify the challenges that firms face as they transition into the wind industry. Finally, based on characteristics of current

suppliers and firms that have already moved from auto manufacturing into wind, this paper offers potential market entry strategies.

The U.S. Value Chain for Wind Energy

Wind turbines convert kinetic energy from wind into mechanical energy that is then converted into electricity through a generator.² Wind turbine equipment is classified into three categories: utility-scale, industrial-scale, and residential-scale. Utility-scale turbines range from 900 kW to 3 MW and are typically installed in large arrays to generate bulk power for sale in power markets. However, these turbines can also be installed in small groups on distribution lines, otherwise known as distributed generation. Industrial-scale turbines range from 50 to 150 kW and are intended for remote grid production, often in conjunction with diesel or load-side generation to reduce consumption of expensive grid power. Residential-scale turbines range from 400 W to 50 kW and are used for remote power, battery charging and net metering generation.³ This paper focuses on the supply chain for utility-scale wind turbines.

The “Danish concept” turbine configuration dominates the North American market. This design uses a horizontal-axis, three blade rotor, upwind orientation, and an active yaw system to keep the rotor oriented into the wind.⁴

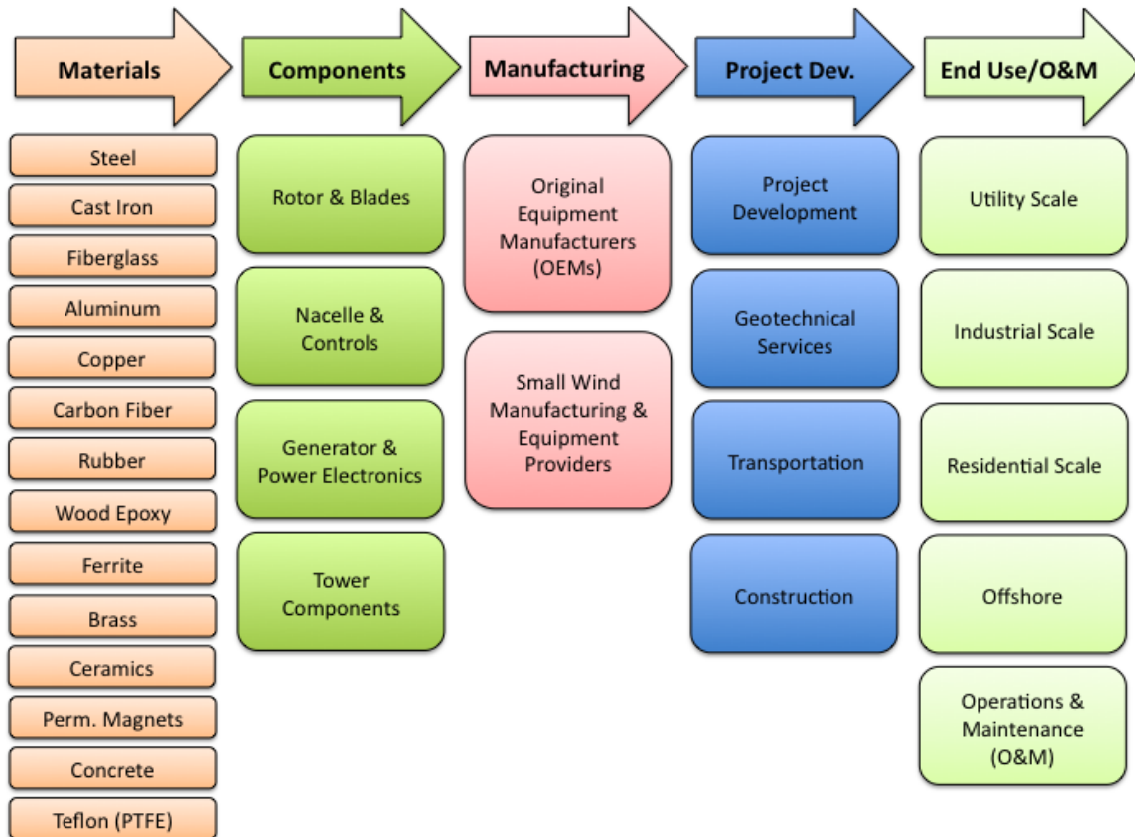
² Ayee, Gloria, Marcy Lowe and Gary Gereffi. “Wind Power: Generating Electricity and Employment.” Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs. Center on Globalization Governance & Competitiveness, Duke University. September 2009.

³ “Wind Turbine Technology.” New York State Energy Research and Development. October 2005.

⁴ Ibid.

The wind power value chain incorporates five main stages: materials, components, manufacturing, project development, and end use and operations and maintenance (O&M). These stages are illustrated in Figure 2.

**Figure 2:
Wind Power Value Chain⁵**



Materials

A wide range of materials are used to produce a finished wind turbine including steel, fiberglass, resins (for composites and adhesives), blade core materials, permanent magnets, and copper. Steel is the primary and most essential material for wind turbines

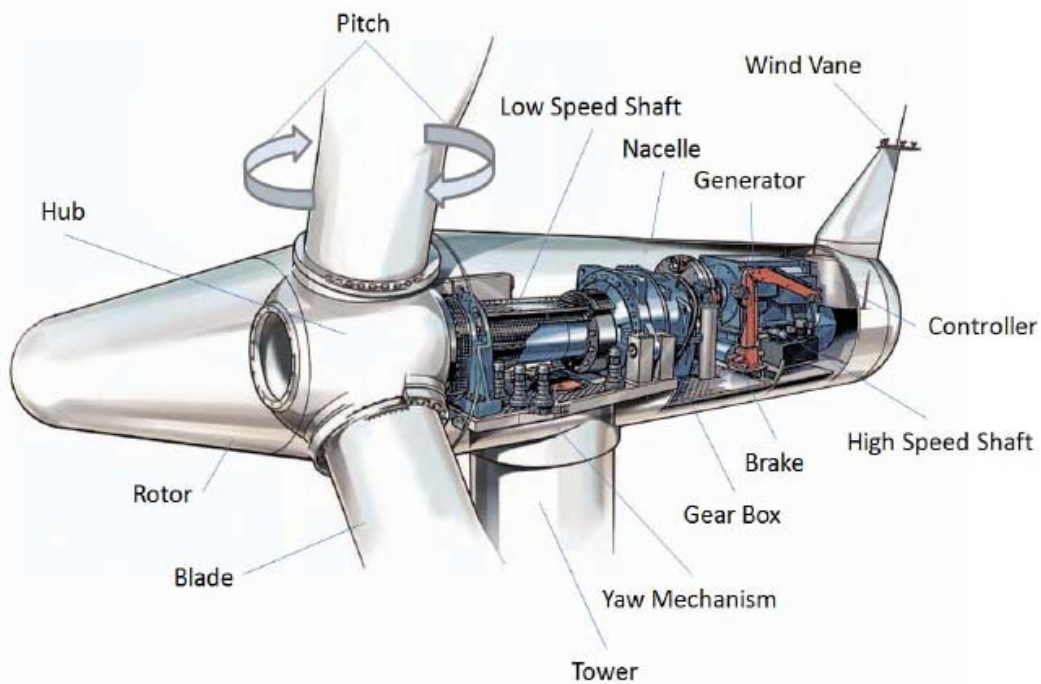
⁵ Adapted from Ayee, Gloria, Marcy Lowe and Gary Gereffi. "Wind Power: Generating Electricity and Employment." Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs. Center on Globalization Governance & Competitiveness, Duke University. September 2009.

due to its strength and durability. Steel will generally account for around 90 percent of the weight, which reaches between 200 and 400 tons for a typical turbine.⁶

Component Parts

There are over 8,000 precision parts in a single wind turbine ranging from the steel tower and high-tech composites for blades, to gearboxes, bearings, electrical wiring and power electronics. These component parts can be grouped into four main categories: rotor and blades, nacelle and controls, generator and power electronics, and tower components.⁷

**Figure 3:
Diagram of Wind Turbine Component Parts**



Source: CGGC-modified Siemens Press Picture (Siemens AG, 2007)

⁶ Ayee, Gloria, Marcy Lowe and Gary Gereffi. “Wind Power: Generating Electricity and Employment.” Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs. Center on Globalization Governance & Competitiveness, Duke University. September 2009.

⁷ Ibid.

The rotor blades use the principle of lift to convert energy of the wind into mechanical energy. The material and design varies depending on the manufacturer, but utility-scale blades are generally 40 to 50 meters in length and made from fiberglass and other composite materials. The rotor hub serves as the base for the blades and houses control systems for the pitch drive, which adjusts that pitch of the rotor blades to maintain the optimum angle for the wind and desired rotation speed.⁸

The nacelle of a wind turbine houses a number of systems and controls that enable a wind turbine to function effectively and produce electricity. A yaw mechanism keeps the turbine oriented directly into the wind (or 90 degrees from prevailing winds under high-wind conditions). An anemometer and wind vane measures wind velocity and direction and relays this information to the yaw mechanism. A cooling system fans cool air towards the generator and exhausts waste heat.⁹

The nacelle also houses the generator and power electronics. A gearbox converts the low-speed rotation of the rotor to higher-speed rotations, which drive the shaft of the generator assembly to convert mechanical energy into electricity. Power electronics generally consist of variable speed drives (VSD) that enable the machines to run smoothly and continuously, regardless of wind speed.¹⁰

⁸ Sterzinger, George and Matt Svrcek. "Wind Turbine Development: Location of Manufacturing Activity." Renewable Energy Policy Project (REPP). September 2004.

⁹ Ibid.

¹⁰ Ayee, Gloria, Marcy Lowe and Gary Gereffi. "Wind Power: Generating Electricity and Employment." Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs. Center on Globalization Governance & Competitiveness, Duke University. September 2009.

Towers for wind turbines are typically made from rolled, tubular steel that are constructed and transported in sections from facilities relatively close to the installation site. Utility-scale towers range in height from 60 to 100 meters and weigh between 200 and 400 tons. A base, generally made from steel-reinforced concrete, transfers the load of the tower to the foundation soil or bedrock. The tower also contains flanges and bolts that join sections of the tower together.¹¹

Manufacturing

The manufacturing and assembly phase consists of several large original equipment manufacturers (OEMs) as well as other small wind manufacturing and equipment providers. This paper will focus primarily on the large OEMs.

OEMs generally manufacture the nacelle in-house, producing some components themselves and sourcing many others from a number of suppliers. Blades and towers are either produced by the OEM or fabricated by a supplier to the OEM's specifications.¹²

The rapid growth of the U.S. wind market has led to increased competition among OEMs. The industry is dominated by a small number of players, including GE Energy, Vestas and Siemens. However, several other companies have entered the U.S. market and are gaining market share. GE Energy captured 43 percent of new capacity and 48 percent of turbines installed in 2008. Vestas holds the second spot, followed by Siemens, Suzlon,

¹¹ Sterzinger, George and Matt Svrcek. "Wind Turbine Development: Location of Manufacturing Activity." Renewable Energy Policy Project (REPP). September 2004.

¹² Ayee, Gloria, Marcy Lowe and Gary Gereffi. "Wind Power: Generating Electricity and Employment." Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs. Center on Globalization Governance & Competitiveness, Duke University. September 2009.

Gamesa, Clipper, Mitsubishi, Acciona WP and REpower.¹³ OEMs that have nacelle assembly facilities in the U.S. include Acciona, Clipper Windpower, DeWind, Gamesa and GE Energy. Siemens, Suzlon and Vestas currently only manufacture blades, but both Siemens and Vestas are planning new facilities in the U.S. to manufacture nacelles.¹⁴

Project Development

Project development for commercial-scale wind farms is a lengthy and complicated process. This includes site selection, feasibility analysis, turbine procurement, permitting, and project financing.¹⁵

This phase of the value chain also includes geotechnical services, transportation, and construction. Transportation presents unique challenges due to the unusual size, weight and shape of turbine components. Geotechnical assessment takes place before construction and is either contracted directly or included as a part of construction companies' turnkey packages.¹⁶

End Use and O&M

The final phase of the value chain for wind power is the end use and operation of wind projects. As discussed earlier in this paper, wind projects, depending on their size, fall in three different categories: utility-scale, industrial-scale or residential-scale. NextEra

¹³ "Annual Wind Industry Report, Year Ending 2008." American Wind Energy Association.

¹⁴ Ayee, Gloria, Marcy Lowe and Gary Gereffi. "Wind Power: Generating Electricity and Employment." Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs. Center on Globalization Governance & Competitiveness, Duke University. September 2009.

¹⁵ Ibid.

¹⁶ Ibid.

Energy Resources, formerly FPL Energy, continues to dominate the ownership of wind assets with a total of 6,290 MW. Other companies owning more than 1,000 MW of wind assets include Iberdrola, MidAmerican Energy, Horizon-EDP Renewables, Invenergy and Babcock & Brown.¹⁷ Independent ownership of wind resources is the most common, with utility-ownership accounting for approximately 15 percent of installations.¹⁸

Operations and maintenance services are crucial to ensuring the reliability and efficient operation of a wind turbine. Manufacturers typically service turbines during the first 2 to 5 years while the equipment is still under warranty. Beyond this point, wind farm operators may perform ongoing maintenance or subcontract to independent service companies.¹⁹

The U.S. Automotive Industry Value Chain

The value chain for the auto manufacturing industry has traditionally been organized into several distinct tiers. Manufacturers or assemblers, such as GM, Ford or Toyota, were responsible for the design and assembly of vehicles as well as marketing and branding activities. Innovation, engineering and design capabilities were critical, especially as first movers in new markets or segments.²⁰ While the Big Three domestic manufacturers were at one time highly vertically integrated, they now have a long history of outsourcing components to a network of suppliers.

¹⁷ “Annual Wind Industry Report, Year Ending 2008.” American Wind Energy Association.

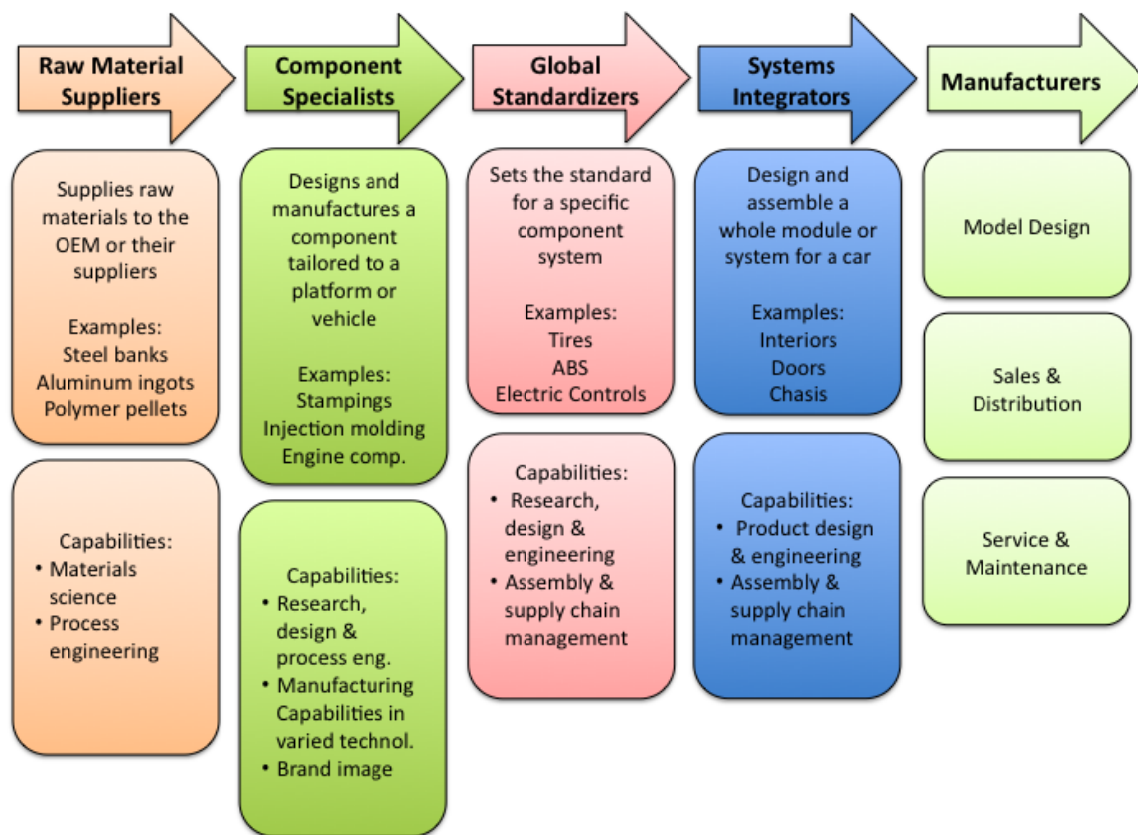
¹⁸ Ibid.

¹⁹ Ayee, Gloria, Marcy Lowe and Gary Gereffi. “Wind Power: Generating Electricity and Employment.” Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs. Center on Globalization Governance & Competitiveness, Duke University. September 2009.

²⁰ “The Global Automotive Industry Value Chain: What Prospects for Upgrading by Developing Countries.” United Nations Industrial Development Organization. 2003.

The overall structure of auto manufacturing in the U.S. is changing with the introduction of “transplanted” units of foreign manufacturers, increasingly global supply chains and heavier dependence on suppliers to provide key components and systems.²¹ The value chain for the auto manufacturing industry can be grouped in four major categories: systems integrators, global standardizers-systems manufacturers, component specialists, and raw material suppliers.²²

Figure 4:
Automobile Manufacturing Value Chain²³



²¹ Cooney, Stephen and Brent D. Yacobucci. “U.S. Automotive Industry: Policy Overview and Recent History.” CRS Report for Congress. April 25, 2005.

²² Veloso, Francisco and Rajiv Kumar. “The Automotive Supply Chain: Global Trends and Asian Perspectives.” Asian Development Bank. January 2002.

²³ Adapted from Veloso, Francisco and Rajiv Kumar. “The Automotive Supply Chain: Global Trends and Asian Perspectives.” Asian Development Bank. January 2002.

Raw Material Suppliers

Raw material suppliers provide raw materials to manufacturers and their suppliers. The market structure and competitiveness of this category varies from material to material. Some of these suppliers are also moving towards becoming component specialists to add value to their products.

Component Specialists

Component specialists design and manufacture specific components or subsystems for a given model or vehicle platform. Firms at this level are typically smaller and supply to system integrators and standardizers. These include “process” specialists, such as metal stampers, die casters, injection molders, or forging shops. These suppliers require process-engineering skills and the ability to meet quality requirements, such as achieving ISO 9001 certification, in order to remain in the market.²⁴ Component manufacturers are responsible for the design and testing of a specific part, but not the design of the entire subassembly where it will fit. However, some firms do have additional capabilities such as machining and assembly. Overall, this category represents the vast majority of firms supplying the auto manufacturing industry.

Global Standardizers

Global standardizer, or systems manufacturers, set the standard for a component or system, such as tires, ABS, and electric controls. These firms are capable of the design,

²⁴ “The Global Automotive Industry Value Chain: What Prospects for Upgrading by Developing Countries.” United Nations Industrial Development Organization. 2003.

development and manufacturing for complex systems and may supply manufacturers directly or indirectly through system integrators. In this stage of the value chain, design and innovation capabilities are important, but the global reach of firms is often more limited than that of Tier 0.5 suppliers.²⁵

System Integrators

Systems integrators, sometimes also referred to as global mega-suppliers or Tier 0.5, design and integrate components, subassemblies and systems into modules that are shipped or placed directly into assemblers' plants. These suppliers operate globally and have substantial design and innovation capabilities in order to deliver "black box" solutions to customers. Black box solutions are those developed by suppliers to meet performance and interface requirements of assemblers, but using their own technology.²⁶

Manufacturers

Finally, manufacturers assemble systems and components to complete vehicles and distribute to a network of dealers for sale to consumers. At this phase of the value chain, companies focus extensively on vehicle and platform design, sales and distribution and service and maintenance.

The U.S. Wind Energy Market

The wind industry has experienced rapid growth since 2000 due to extensions of the production tax credits (PTCs), rising concerns about climate change, emergence of

²⁵ "The Global Automotive Industry Value Chain: What Prospects for Upgrading by Developing Countries." United Nations Industrial Development Organization. 2003.

²⁶ Ibid.

renewable portfolio standards (RPS) in many states and improved turbine technology and performance.²⁷ The U.S. is now one of the largest markets for wind energy; it has the highest installed capacity and leads the world in new installations. By the end of 2008, the U.S. had an installed wind generation capacity of 25,369 MW, with an addition of 8,545 MW in that year alone. These installations represented 17 billion in investments and 42 percent of total power-production capacity added in 2008.²⁸ Wind energy generated 52 million MWh in 2008, representing 1.26 percent of the nation's total electricity demand – a sharp increase from 2007 when 34.5 million MWh (0.83 percent) were generated from wind.²⁹

In recent years, the wind industry has witnessed the following trends:

- *Larger Projects.* The U.S. market is witnessing a growth in the number of large-scale wind projects. In 2006, eight of the 45 installations completed were over 100-MW and the largest project, the Horse Hollow Wind Energy Center in Texas, had a total capacity of 736 MW.³⁰ In 2008, more than 35 projects over 100 MW came online and the largest project scheduled for 2009 will reach over 780 MW.³¹
- *Larger Turbines.* Wind turbines are becoming increasingly powerful and the average capacity of installed machines rose from 1.60 MW in 2007 to 1.67 MW in 2008. With models in the 2 to 3 MW range now reaching the U.S. market, this figure is expected to increase more sharply in the next few years.³²

²⁷ “20% Wind Energy by 2030.” U.S. Department of Energy. July 2008.

²⁸ “Annual Wind Industry Report, Year Ending 2008.” American Wind Energy Association.

²⁹ Ibid.

³⁰ American Wind Energy Association. Wind Power Outlook 2007.

³¹ American Wind Energy Association. Wind Power Outlook 2009.

³² Ibid.

- *Increased Competition.* The large U.S. market is attracting new players. The number of utility-scale manufacturers selling equipment in the U.S. rose to 14 in 2008, up from 8 in 2007 and 6 in 2006.³³
- *More Domestic Manufacturing.* Continued growth in the U.S. wind power market has led to a rise in domestic manufacturing capability. Six of the top ten utility-scale wind turbine manufacturers now have production facilities in the U.S. The rise of component and material manufacturing has been even more noteworthy. More than 70 manufacturing facilities were announced, opened or expanded in 2007 and 2008.³⁴
- *More Available Capital.* While the current financial crisis stalled capital for wind projects in recent years, the high growth potential in wind energy has made it an attractive investment opportunity and, in sharp contrast to the 1990s, today's financiers represent a broad base of U.S. and international institutions.³⁵ Wind's strong growth potential and the support of the Obama Administration has led capital to slowly start flowing into the industry again.³⁶

With the growing size of turbines and projects, wind has reached economies of scale that are bringing it closer to competing with traditional generation technologies. Subsidies and other incentives have played a tremendous role in reaching these economies of scale, such that at some point in the future they will no longer be necessary.

³³ American Wind Energy Association. Wind Power Outlook 2009.

³⁴ Ibid.

³⁵ American Wind Energy Association. Wind Power Outlook 2007.

³⁶ American Wind Energy Association. Wind Power Outlook 2009.

In July 2008, the U.S. Department of Energy published a report entitled “20% Wind Energy by 2030,” which presents a scenario for achieving 20% wind penetration in the U.S. The U.S. Energy Information Administration estimates that electricity demand will grow by 39 percent from 2005 to 2030, reaching a total of 5.8 billion megawatt-hours (MWh). Meeting 20 percent of that demand would thus require wind power capacity of more than 300 gigawatts (GW) – representing an increase of more than 290 GW within 23 years.³⁷ The 2030 scenario implies that new wind installations would grow to more than 16,000 MW per year by 2018 and continue at that rate through 2030.³⁸

Constraints for U.S. Wind Turbine Manufacturing

The rapid growth of the wind power industry in the U.S. has accelerated domestic manufacturing activity. Over the past two years, wind turbine and turbine component manufacturers announced, added or expanded over 70 facilities. These facilities, once fully online, will create 13,000 new direct jobs and represent nearly \$2 billion in investment.³⁹

As domestic manufacturing capacity expands, manufacturers face shortages of domestic suppliers of wind turbine components. While the current economic recession and the resulting slowdown in manufacturing and orders for wind turbines has eased these shortages, this presents a long-term supply issue for OEMs.⁴⁰

³⁷ “20% Wind Energy by 2030.” U.S. Department of Energy. July 2008.

³⁸ “Annual Wind Industry Report, Year Ending 2008.” American Wind Energy Association.

³⁹ Ibid.

⁴⁰ Ayee, Gloria, Marcy Lowe and Gary Gereffi. “Wind Power: Generating Electricity and Employment.” Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs. Center on Globalization Governance & Competitiveness, Duke University. September 2009.

Materials

Steel is not expected to be a limiting resource, especially because it is a recyclable resource and can continue to be used for applications requiring less high-quality steel.⁴¹

Permanent magnets, which are expected to become an economical substitute to copper in the generator, are not expected to be supply restricted but will require an increase in manufacturing capacity.⁴² This may be a concern in the U.S. as the key magnetic materials are not obtainable domestically. Copper and laminate steel, both used in generator manufacturing, are another supply constraint that contributes to a potential supply bottleneck for generators.⁴³

The current fiberglass production capacity is not sufficient to meet the anticipated demand for wind turbines, requiring construction of new fiberglass furnaces. Additionally there is a limited and fluctuating supply of resins, adhesives and cores used to impregnate the fiberglass.⁴⁴

As design innovations change the primary materials used, potential resource restrictions may emerge. This may include balsa wood for the blade core, due to the growth rate of balsa trees and carbon fiber, another potential lightweight blade material.⁴⁵

⁴¹ “20% Wind Energy by 2030.” U.S. Department of Energy. July 2008.

⁴² Ibid.

⁴³ Ayee, Gloria, Marcy Lowe and Gary Gereffi. “Wind Power: Generating Electricity and Employment.” Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs. Center on Globalization Governance & Competitiveness, Duke University. September 2009.

⁴⁴ “20% Wind Energy by 2030.” U.S. Department of Energy. July 2008.

⁴⁵ Ibid.

Components

The majority of turbines currently installed in U.S. are imported from Europe and Asia. However, the percentage of wind turbine components manufactured domestically grew from less than 30 percent in 2005 to 50 percent in 2008, by value.⁴⁶

Rapid growth in the wind industry has placed significant pressure on component suppliers to meet demands of the OEMs, who are implementing different strategies, such as vertical integration or signing long-term contracts, to secure supply of necessary components.⁴⁷

Gearboxes and large bearings are the most significant component supply bottleneck, with generators as a distant third.⁴⁸ These components are only manufactured by a small number of firms globally. For many of these suppliers, wind represents a small percentage of their total sales and thus is not a priority for investment and growth. The limited supply of large bearings, which are used in a number of parts (including the gearbox) further compounds the bottleneck for gearboxes.⁴⁹

Manufacturing

Producing 100,000 wind turbines over the next 20 years as the US DOE's 20% by 2030 scenario implies a significant amount of new or re-purposed manufacturing capacity.

⁴⁶ Ayee, Gloria, Marcy Lowe and Gary Gereffi. "Wind Power: Generating Electricity and Employment." Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs. Center on Globalization Governance & Competitiveness, Duke University. September 2009.

⁴⁷ Ibid.

⁴⁸ "Electrical Components for the Wind Industry." AWEA Wind Power Value Chain.

⁴⁹ "Supply Chain: The Race to Meet Demand." Wind Directions. January/February 2007.

While this is not expected to be a major constraint, reaching sufficient manufacturing levels will necessitate a modest increase in plant capacity factors.⁵⁰

Many foreign OEMs are building production capabilities in the U.S. to compete more effectively in the world's largest market. Vestas, for example, will begin production of nacelles in Windsor, CO in early 2010. This manufacturing plant is expected to produce 1,000 turbines per year.⁵¹ Vestas is already producing blades and towers in separate facilities nearby in Colorado.

Although there are significant advantages to manufacturing large components such as towers and blades near their point of end use, U.S. labor rates can be prohibitive to new manufacturing facilities. The 2030 Scenario notes that one blade manufacturer with significant international manufacturing experience estimates that, to make a U.S. factory competitive, the labor hours per blade would need to be reduced by 30 to 35 percent.⁵²

The U.S. Auto Manufacturing Industry

In many ways, wind turbine manufacturing in the U.S. mirrors past trends in the auto industry. In the 1950s and 1960s, the auto manufacturing industry was highly concentrated among a small number of companies and, as the market shares suggest, not very competitive. As new players entered the market, including foreign transplants, the competitiveness of the market increased dramatically and the dominance of Detroit

⁵⁰ "20% Wind Energy by 2030." U.S. Department of Energy. July 2008.

⁵¹ Daly, Pete. "Auto Suppliers Curious about Wind Turbines, Medical Supplies and Aerospace." Grand Rapids Business Journal, March 4, 2009.

⁵² "20% Wind Energy by 2030." U.S. Department of Energy. July 2008.

manufacturers gradually declined. This shift led to more choices, better quality and improved affordability for consumers.

The auto industry has faced a mature market for the past ten years, with stagnant demand, product proliferation and stiff price competition. The demand for new cars has been growing on average less than 1 percent per year and this trend is expected to continue.⁵³

Today, the economic downturn is affecting all carmakers, with those in Detroit struggling for their very survival and even the market leader, Toyota, reporting losses.

In recent years, design, brand management and customer relationships have become increasingly important to auto manufacturers. This is leading manufacturers to adjust their business models to capture more of the value chain that links them to customers, such as dealerships and service. As a result, they are becoming somewhat less involved in manufacturing and assembly, passing more and more of this role along to their suppliers.⁵⁴

Despite the heavy reliance of manufacturers on their suppliers, these firms still face a number of pressures. As manufacturers develop more models to fill various market niches, they are also reducing costs by using fewer “platforms.” This leads to a greater commonality of parts and reduces the number of suppliers needed. GM and Ford are also sourcing more components from low-cost regions, China in particular. On the upstream side, the rising cost of materials, especially steel, makes it difficult for suppliers to

⁵³ Veloso, Francisco and Rajiv Kumar. “The Automotive Supply Chain: Global Trends and Asian Perspectives.” Asian Development Bank. January 2002.

⁵⁴ Ibid.

continue to reduce prices for customers. With these pressures, similar to the assemblers, the vehicle parts industry will face consolidation.⁵⁵

Opportunities in Wind Energy for the Automotive Industry

As OEMs build their U.S. supply chains, new opportunities are being created for companies to serve the wind industry. These opportunities arise not only from the increase in manufacturing of wind turbines, but also from OEMs desire to source components locally and relieve existing supply constraints for certain components. Turbine manufacturers are looking to source most, if not all, of their components domestically as transportation costs can reach up to 20 percent of total costs and there may also be a foreign exchange benefit.⁵⁶ Limited domestic production capacity is creating supply constraints for some components, especially gearboxes and large bearings, which contribute towards an upward pressure on turbine prices. Off-the-shelf prices increased by over 65 percent between 2004 and 2008, largely due to the global squeeze on production capacity.⁵⁷

Current manufacturing capacity for wind turbines and component parts is not sufficient to meet demand. Customs data reports an increase in wind turbine imports from Europe and Asia; by value, these imports increased from \$60 million in 2004 to \$2.5 billion in 2008. The growth in imports highlights an opportunity for domestic firms to capture some of

⁵⁵ Cooney, Stephen and Brent D. Yacobucci. "U.S. Automotive Industry: Policy Overview and Recent History." CRS Report for Congress. April 25, 2005.

⁵⁶ Schoof, Renee. "Wind Turbine Imports Increase; Can U.S. Factories Catch Up?" *McClatchy Newspapers*. April 19, 2009.

⁵⁷ Radomski, Dan. "Supplier Opportunities for Manufacturing Wind Energy Systems in Michigan." Power Point Presentation. June 27, 2008.

this supply market. The growth rate of imports has started to level off and increased by only 100 million between 2007 and 2008, a period when the wind industry was still growing quickly, suggesting that domestic manufacturing has met some of this demand.⁵⁸

Given the needs of wind OEMs as they expand production and demand more component parts, it is important to assess whether there is an opportunity for firms supplying the auto industry. Wind turbines contain many parts, such as generators, bearings, drive shafts and controls, which are similar to comparable parts in motor vehicle drive trains.⁵⁹ In recent years, suppliers have also taken a greater role in research, engineering and development of components for vehicles.⁶⁰ Suppliers to the auto industry thus possess many of the capabilities and resources needed to manufacture components for wind turbines.

Geographic Distribution of Wind Turbine and Auto Manufacturing

An important factor contributing to the attractiveness for firms involved in auto manufacturing to transition into wind turbine production is the geographic overlap between the two industries. Wind is positioned to absorb many of the manufacturing jobs that have been lost recently in auto manufacturing.⁶¹ Firms can retrofit existing manufacturing facilities and access skilled labor with expertise in the advanced precision

⁵⁸ Schoof, Renee. "Wind Turbine Imports Increase; Can U.S. Factories Catch Up?" *McClatchy Newspapers*. April 19, 2009.

⁵⁹ McCabe, Loch in an interview by Brad F. Kuvin. "Wind and Solar Energy: Where are the Opportunities for Metalformers?" *Metalforming*. Special Online-only issue, 2009.

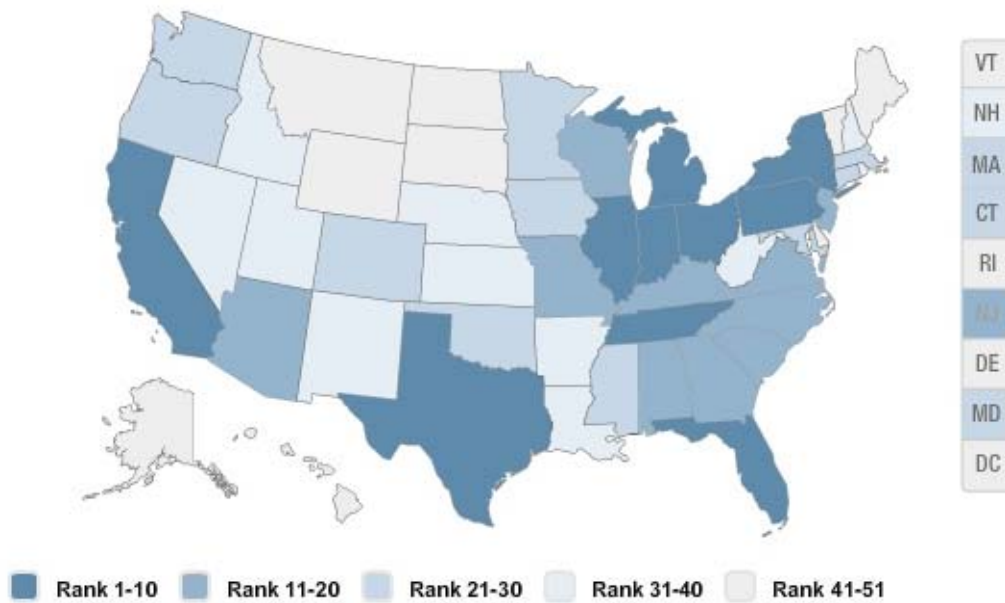
⁶⁰ Veloso, Francisco and Rajiv Kumar. "The Automotive Supply Chain: Global Trends and Asian Perspectives." Asian Development Bank. January 2002.

⁶¹ Schoof, Renee. "Wind Turbine Imports Increase; Can U.S. Factories Catch Up?" *McClatchy Newspapers*. April 19, 2009.

manufacturing needs of the wind industry.⁶²

The automobile manufacturing industry grew out of the Great Lakes region and Detroit, MI in particular. Figure 5 below captures state employment in the auto industry and illustrates the concentration of activity in the auto industry around the Great Lakes.

**Figure 5:
Employment in the Auto Industry, by State⁶³**



As the value chain for the auto industry has evolved and the dominance of the Big Three fades, the geographic distribution is changing somewhat. The core of the industry, including its supplier base, is shifting from the traditional Midwest “auto belt” to the Sunbelt and other locations in the South and West. Michigan has lost over 100,000 jobs

⁶² Ayee, Gloria, Marcy Lowe and Gary Gereffi. “Wind Power: Generating Electricity and Employment.” Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs. Center on Globalization Governance & Competitiveness, Duke University. September 2009.

⁶³ “U.S. Auto Industry Broken Down by State.” CNN.com. <http://www.cnn.com/2008/US/12/12/map.us.auto/index.html>.

in auto manufacturing since its peak in the late 1970s.⁶⁴

Despite this observed shift, the fundamental geographic patterns of the industry will not change quickly. The sunk capital, accumulated labor force skills and the deep supply base that exist in the Midwest make a complete redistribution of the industry highly unlikely.⁶⁵

However, this geographic shift and the contraction of manufacturing activity in the Midwest leaves a number of skilled workers and suppliers in that are eager to diversify into new industries.

The wind manufacturing industry has also emerged in the Midwest and Great Lakes region. The proximity to good wind resources, rail transportation, labor and facilities has made these areas a good fit for wind OEMs and component suppliers. Michigan and several other states in this region offer a strong manufacturing infrastructure and workforce, including skilled engineering talent and many firms experienced in producing complex parts.⁶⁶ The Michigan Economic Development Corporation estimates that approximately 700 companies are participating or beginning to participate in the wind power manufacturing industry and Ohio's Department of Economic Development reports that 532 companies are involved or have plans to become involved in the wind supply chain.⁶⁷ Many state and local governments have also offered substantial incentives to

⁶⁴ Cooney, Stephen and Brent D. Yacobucci. "U.S. Automotive Industry: Policy Overview and Recent History." CRS Report for Congress. April 25, 2005.

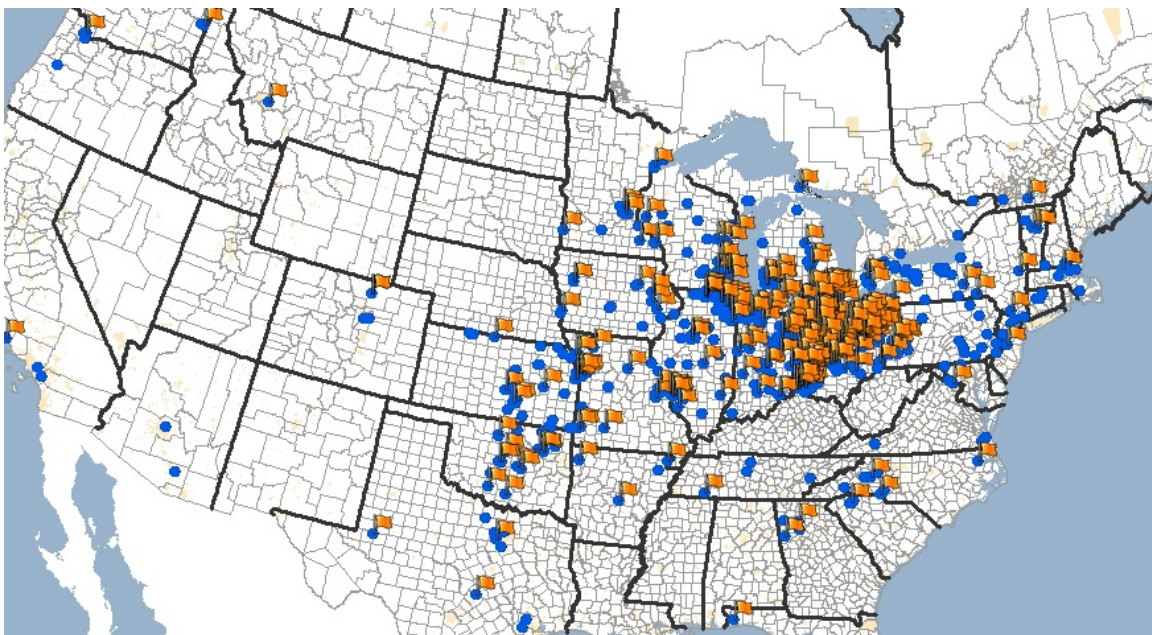
⁶⁵ Sturgeon, Timothy J., Johannes Van Biesebroeck and Gary Gereffi. "The North American Automotive Value Chain: Canada's Role and Prospects." *International Journal of Technological Learning, Innovation and Development*. Vol. 2, Nos 1/2, 2009.

⁶⁶ Radomski, Dan. "Michigan Wind Energy Symposium." Power Point Presentation. September 10, 2007.

⁶⁷ Ayee, Gloria, Marcy Lowe and Gary Gereffi. "Wind Power: Generating Electricity and Employment." Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs. Center on Globalization Governance & Competitiveness, Duke University. September 2009.

encourage the development of wind manufacturing in their states. Figure 6 below illustrates the geographic distribution of wind OEMs as well as active and emerging component suppliers to the wind industry. These groups are captured by the orange flags.

Figure 6:
Geographic Distribution of Wind OEMs and Suppliers⁶⁸



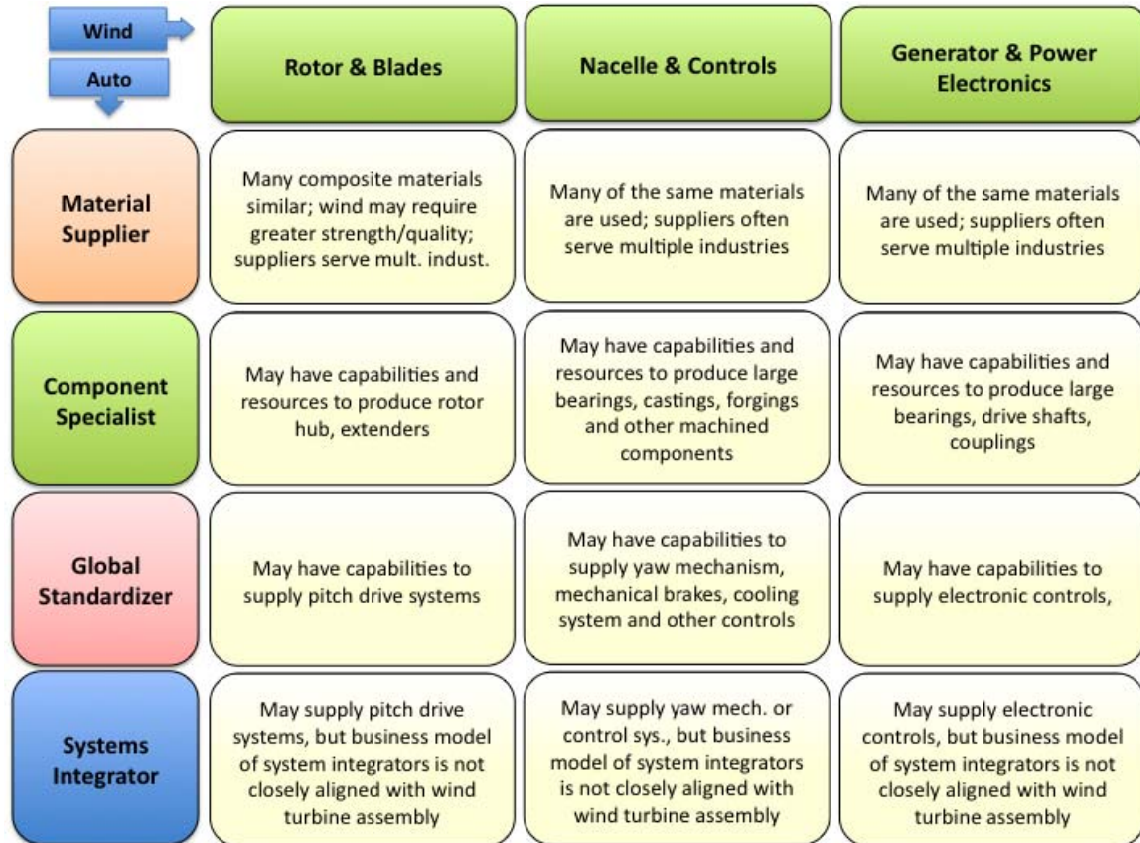
Overlap between the Wind Energy and Auto Manufacturing Value Chains

The matrix on the following page illustrates the overlap between the wind turbine component groups and the auto manufacturing value chain. Note that this figure does not include wind turbine towers as this component not a likely fit for auto suppliers.

⁶⁸ Wind Supply Map and Data. Great Lakes Wind Network. www.glwn.org.

Figure 7:

Overlap of Wind Turbine Components and the Auto Manufacturing Value Chain



Many of the materials for wind turbines and automobiles are similar, if not the same, and material suppliers in the auto industry can thus reach new customers in wind with relative ease. Most of these suppliers are already diversified across several industries and will not be a focus of this paper.

Component specialists, which focus on the design and production of components tailored to a specific vehicle or platform, are perhaps the best positioned to expand into the wind industry. Due to their experience customizing parts, component specialists have the

design, engineering and manufacturing capabilities necessary to produce wind components in accordance with the precise specifications of wind turbine OEMs. The equipment and manufacturing processes are also similar.⁶⁹ These firms may, however, face limits in terms of the size of the components they are able to produce and also the quality standards that customers in wind expect. Many component specialists need to make substantial investments to effectively serve customers in the wind industry.

Global standardizers may have the capabilities to produce pitch drive systems, yaw mechanisms, braking systems, electronic controls and other related systems. However, the opportunity in wind is limited as many OEMs vertically integrate these components or are hesitant to try new suppliers for such technologically advanced control systems. Similarly, systems integrators may have the capabilities to produce certain components for wind turbines, but the assembly strategy of wind OEMs is substantially different from that of the auto industry. In the auto industry, systems integrators work very closely with assemblers and deliver completed systems directly into their customers' facilities. In wind, few components are assembled as complete systems and OEMs do not typically maintain such close relationships with suppliers. As such, the wind industry may not be a good strategic fit for many system integrators.

Challenges for Automotive Suppliers Entering the Wind Industry

Wind turbine OEMs are moving forward quickly and aggressively to develop their U.S. supply chains. While some are pursuing extensive vertical integration, many are also

⁶⁹ Ayee, Gloria, Marcy Lowe and Gary Gereffi. "Wind Power: Generating Electricity and Employment." Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs. Center on Globalization Governance & Competitiveness, Duke University. September 2009.

looking for new suppliers that can produce needed parts with extremely high quality, maintain just-in-time deliveries, have the flexibility to accommodate design changes and innovations, and possess the financial strength to make investments and grow along with the wind industry.⁷⁰ High expectations and fundamental differences between wind turbine and auto manufacturing presents a number of market entry challenges including high capital costs, high product specification, the low volume-high margin business model, shortages of machines and other tools, limited equipment resale value, immature and fast-paced industry and market sensitivity to public policies and incentives.⁷¹

One challenge for all firms looking at entering the wind power value chain has been the boom and bust nature of the industry. Unstable public policies supporting renewable energy development drove periods of high growth, followed by stagnation in wind project development. This lack of stability is a major challenge for firms seeking to assess a new or expanded market opportunity. The manufacturing sector needs a viable political environment, financial incentives and greater evidence of a real business opportunity to support the necessary long-term investments.⁷² With the exception of the current economic recession, wind development has become much more stable in recent years and is expected to continue to grow. This is a positive sign, but as financing for wind projects stalled over the last year, many companies that have made the shift to wind or are in the process of doing so have put their business on hold as well.⁷³

⁷⁰ Radomski, Dan. "Supplier Opportunities for Manufacturing Wind Energy Systems in Michigan." Power Point Presentation. June 27, 2008.

⁷¹ Ibid.

⁷² Radomski, Dan. "Michigan Wind Energy Symposium." Power Point Presentation. September 10, 2007.

⁷³ Schoof, Renee. "Wind Turbine Imports Increase; Can U.S. Factories Catch Up?" *McClatchy Newspapers*. April 19, 2009.

The difference in the volume of production presents a substantial challenge and business model shift for firms in the auto industry as they transition to producing wind turbine components. The wind industry operates on a low volume-high margin model that is atypical for the auto manufacturing industry, which is accustomed to producing *millions* of vehicles per year. Auto component suppliers must evolve their business model from high volume-low margin to low volume-high margin production.⁷⁴

The large size of wind turbines and their components presents a barrier for a number of firms in the auto industry. Parts for wind turbines generally fall into two categories – those over 6,000 pounds and those less than 600 pounds. Suppliers to auto manufacturing may not have the equipment and resources to produce the largest parts. Current suppliers of these components often cast, forge, machine and fabricate heavy-duty, large scale parts for other industrial, construction and mining customers. European standards, which are prevalent across all wind OEMs also require an adjustment for potential new suppliers.⁷⁵

Rigorous quality and delivery standards can be difficult for firms accustomed to the auto industry. Wind turbines must operate under harsh conditions for 20 years or more and are not readily accessible to make repairs. OEMs thus place a high importance on quality control of components and the manufacturing process and often require, at a minimum, an excellent quality track record, rigorous internal quality monitoring, controlled processes and ISO 9001 certification. Most OEMs also insist on just-in-time deliveries

⁷⁴ Daly, Pete. “Auto Suppliers Curious about Wind Turbines, Medical Supplies and Aerospace.” Grand Rapids Business Journal, March 4, 2009.

⁷⁵ McCabe, Loch in an interview by Brad F. Kuvin. “Wind and Solar Energy: Where are the Opportunities for Metalformers?” *Metalforming*. Special Online-only issue, 2009.

and impose strict delivery schedules and penalties on suppliers. The sales process for wind turbine components is also much longer and it can take 12 to 18 months from initial discussion with an OEM and the receipt of an order.⁷⁶

Timing investments to grow along with the rapidly accelerating wind industry poses another challenge. OEMs expect their valued suppliers to increase production to meet increases in demand, requiring repeated investments in equipment, facilities, people and capabilities.⁷⁷ Similarly, potential new suppliers must also make large and risky investments to acquire specialized equipment and build or expand manufacturing facilities.⁷⁸

Finally, while wind OEMs are looking to build and strengthen their U.S. supply chain, utility-scale wind is a global industry and firms must ultimately compete with veteran manufacturers in Europe and Asia.⁷⁹ The opportunity for component manufacturers is also affected by OEMs decisions to vertically integrate or outsource.⁸⁰

Strategies for Potential New Entrants to the Wind Industry

Although the overlap between the wind energy and auto manufacturing value chains is somewhat limited and there are many other challenges for new entrants to the wind industry, there is still an opportunity for some firms in the auto industry to make the

⁷⁶ McCabe, Loch in an interview by Brad F. Kuvin. "Wind and Solar Energy: Where are the Opportunities for Metalformers?" *Metalforming*. Special Online-only issue, 2009.

⁷⁷ Ibid.

⁷⁸ Radomski, Dan. "Michigan Wind Energy Symposium." Power Point Presentation. September 10, 2007.

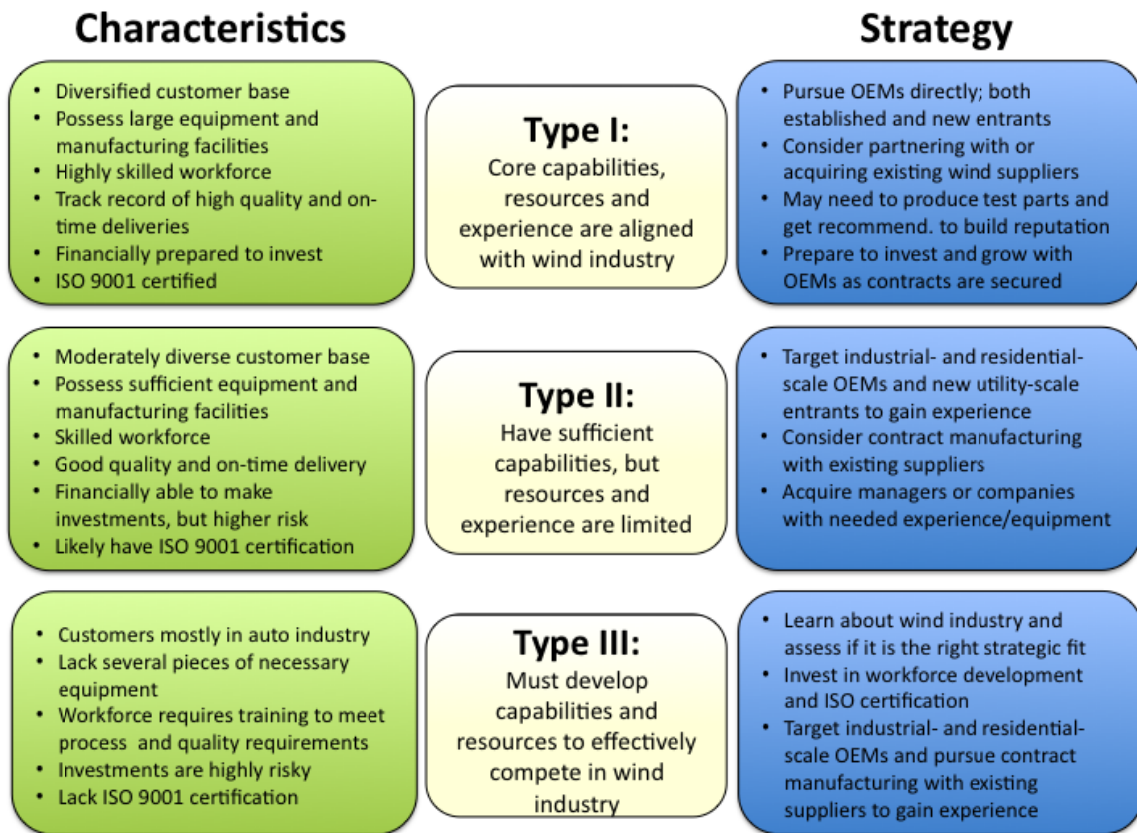
⁷⁹ McCabe, Loch in an interview by Brad F. Kuvin. "Wind and Solar Energy: Where are the Opportunities for Metalformers?" *Metalforming*. Special Online-only issue, 2009.

⁸⁰ Radomski, Dan. "Michigan Wind Energy Symposium." Power Point Presentation. September 10, 2007.

transition into wind.

The following diagram provides an outline of the resources and capabilities that are characteristic of the different types of firms in the automobile manufacturing sector that are considering growth into wind. The graphic also summarizes the most appropriate strategies these firms should employ to transition their businesses.

**Figure 8:
Characteristics and Strategies for Firms Entering the Wind Industry**



Type I firms are expected to have the least trouble transitioning into the wind industry. These companies possess many of the core capabilities and resources needed to serve wind OEMs effectively and have extensive experience working across a diverse customer base, including those in mining, transportation and other heavy industries. Type I firms have developed a reputation for quality, are ISO 9001 certified and can document an excellent track record for on-time deliveries. These firms have a highly skilled workforce and most of the necessary equipment to produce wind turbine components, including machines and manufacturing floor space to handle large parts. Finally, these firms are in a good financial position and will be able to make investments to grow along with the wind industry.

In order to transition into the wind industry, Type I firms are capable of pursuing both established and new OEMs in the U.S. market directly. The sales process may be simplified through a partnership or an acquisition of an existing supplier to wind turbine manufacturers that have an established customer relationship. For Type I firms, one of the most important steps for successfully entering the wind industry will be to build a strong reputation in wind as a strong reputation in other industries will carry little weight with potential customers. Firms should be prepared to produce sample parts and secure recommendations that are representative of quality and timeliness.

Hodge Foundry, a specialty engineering foundry that manufactures complex iron castings, is an example of a Type I firm that has already made the transition into the wind industry. Prior to entering wind, Hodge served customers in a number of industries,

including extensive work in the mining industry, which prepared the firm to begin producing wind turbine components. While Hodge needed to develop its casting process and learn to work with the iron specifications required by wind OEMs, its control process was already fully in place. Starting with one customer, Hodge progressed up the learning curve and made investments to upgrade its facilities, personality and technology. Hodge Foundry now produces rotor hubs, gearbox housings, support bases and other large castings for Clipper Wind and other OEMs.⁸¹

Type II firms have many of the capabilities necessary to serve OEMs in the wind industry, but lack some of the resources and experience that would make entry into this new market easier. A characteristic firm in this group serves a number of different industries, but fewer in heavy industries than a Type I firm. These companies possess much of the equipment needed, but are likely limited by size and may be missing a few key tools or pieces of equipment. Type II firms support a skilled workforce, but some training and development will be needed. From a financial standpoint, companies in this grouping are able to make investments but the risk profile is higher. Most Type II firms will have achieved ISO 90001 certification.

Strategies that are likely to be most effective for Type II firms seeking to enter the wind industry will be to pursue industrial- and residential-scale OEMs as well as new entrants to the utility-scale market in the U.S. Gaining experience with these firms will be important to establish a foothold in wind. Type II firms should also pursue contract manufacturing opportunities for existing suppliers to gain the experience producing wind

⁸¹ Bates, Charles. "Work the Wind." *American Machinist*. August 12, 2009.

turbine components without encountering the lengthy sales process. These firms can also benefit by hiring managers from wind OEMs or existing wind suppliers, or acquiring firms with equipment, capabilities and experience serving the wind industry.

AFCO Precision Manufacturing embodies a Type II firm that has moved into the wind industry successfully. AFCO designed and built coil-processing equipment for several domestic and foreign automakers. Through a subcontract arrangement, AFCO began work in the wind industry by adding contract machining to its existing work. This work was indirect, but gradually allowed AFCO to build its reputation in the wind industry. Now, Green Energy, which produces a “wind cube” turbine designed for rooftops in urban areas is AFCO’s largest client. AFCO’s strongest assets include its large equipment and ample manufacturing floor space that can accommodate wind turbine components, which along with its experience with Green Energy enable the firm to begin targeting utility-scale OEMs.⁸²

Finally, Type III captures those firms may be able to develop the capabilities and resources to gain entry into the wind industry, but it represents high levels of risk and may not be the best strategic direction. These firms serve customers mostly in the industry and do not have the diverse experience or much of the large equipment that many wind components require. The workforce at Type III firms requires substantial training to meet the quality and process requirements set by most wind OEMs and the companies generally lack ISO 90001 certification.

⁸² Bates, Charles. “Work the Wind.” *American Machinist*. August 12, 2009.

The first and most important strategy for Type III firms is to learn as much as possible about the wind industry and supplier requirements and assess if the opportunity in wind is a reasonable fit for the company and its capabilities. If so, these firms should focus first on investing in workforce development and ISO certification. These investments can provide business benefits across a number of industries and thus do not tie the firm to a new and risky industry. Type III firms should then target industrial- and residential-scale OEMs and pursue contract manufacturing relationships to gain experience and demonstrate capabilities, quality and timeliness.

Dowding Industries, Inc. may represent firms that fall into this last group. With auto parts manufacturing representing nearly 100 percent of its sales, Dowding borrowed \$12 million to invest in a transition to a “green” future in wind. After two years, the firm has a new plant and machinery, but little –if any– business with customers in renewable energy. They found that breaking into the wind industry has been harder than expected, particularly during the current economic recession.⁸³

Conclusion

Growth in wind development and turbine manufacturing in the U.S. is creating opportunities for auto component suppliers to enter the wind energy value chain. Some firms are well positioned in terms of their capabilities and resources to transition their business and begin delivering wind turbine components to OEMs. The most successful firms are likely to be component specialists that can build upon their core capabilities and for whom wind is not a major adjustment. These are firms that already serve customers

⁸³ Hedgepeth, Dana. “Shift to Wind Turbines is Hardly a Breeze.” *Los Angeles Times*. August 24, 2009.

across several industries and will not need to invest heavily in order to enter the wind energy value chain. Companies that need to substantially change their business model and expand their capabilities will have a much more difficult experience breaking into the wind industry. These firms cannot assume that manufacturing wind turbine components will immediately improve their financial performance and many will conclude that wind is not a good fit for their business.