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Identifying Opportunities for Swedish Component and Service Suppliers within the US Wind Energy Industry

- Through an Innovation System Perspective

Master of Science Thesis in the Master Degree Programme Management and Economics of Innovation

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ABSTRACT

This master thesis provides an overview of the US wind energy industry through an innovation system analysis thus covering both policy development as well as industry development. It focuses on the recent years of extraordinary growth of installed wind capacity that the US has experienced and the bulk of the empiric data focuses on four broader context issues; policy issues, electrical infrastructure, technology development and the industry supply chain development. The outcome of the Innovation Systems analysis is interpreted as potential business opportunities for Swedish component and service suppliers and the analysis also elaborates on some potential entry strategies as well as barriers.

Keywords: innovation system, US wind energy industry, business opportunities, renewable energy policy

EXECUTIVE SUMMARY

During the years 2006-2008 the US accounted for the highest global share of annual installed capacity and in 2008 it surpassed Germany as the world leader in terms of installed capacity. Although the industry was expecting a slowdown in 2009 due to the economic downturn, 2009 became another record braking year with 9,900 MW newly installed capacity. This was much thanks to the stimulus bill, the American Recovery and Reinvestment Act (ARRA), and it has been estimated that wind generation will be more than twice as much by 2012 than with the no stimulus case. This great expansion of the industry within a relatively short time frame has led to some broader issues of concern for the future development. This master thesis has identified these to be the development of a domestic supply chain, regulatory issues, transmission issues and technology development when it comes to.

First and foremost the lack of a domestic supply chain have already been proven crucial during the period 2007-2008 when there was a large shortage of supply of the majority of key components. This was mainly a consequence of these components being sourced from Europe causing significantly longer lead-times than necessary. This period of critical shortage has led the buildup of a somewhat larger domestic supply chain where new manufacturing facilities have been opened up by turbine manufacturers and as a consequence component suppliers have dared to follow their customers. However turbine manufacturers are still sourcing a vast majority of components from abroad and the domestic supply chain is still largely lacking in comparison to the industry's size. Now turbine manufacturers are strongly encouraging this build-out to avoid future risks associated with transportation, long lead times and exchange rates etc.

When it comes to policy the most important incentives for wind energy has historically been the production tax credits (PTC) together with the state renewable portfolio standards (RPS). However 2009 was an exceptional year when it comes to incentives for wind due to ARRA and the seemingly strongest impact was that of the Investment Tax Credit issued under ARRA. Historically the uncertainty regarding the PTC's renewal has caused boom bust cycles for the industry where a significant decrease in newly installed capacity has been witnessed when the PTC has been allowed to fully expire and the industry is now wondering what will happen after 2012 when the current PTC and the ITC both expire.

Further AWEA is now strongly promoting a federal RPS since the impact of the state RPS's have been proven very effective. The Clean Energy and Security Act of 2009 that was voted through the House in June 2009 included both a federal RPS and a cap and trade scheme. However the development in the Senate regarding a federal climate and energy bill seems to hinder the development. Experts within the industry argue that the strongest regulatory driver for renewable energy in the short term would be a federal RPS however the strong polarization of current US politics then implementation of such a tool is much more volatile.

The large expansion of newly installed capacity has led to increased loads on the electrical infrastructure and as a consequence some projects have already been curtailed due to the congestion. Since the grid was historically developed on a regional basis there is little interconnection between the different states and regions which becomes a problem when the windiest regions are located in rural areas far from the populated areas in need of the electricity. The future solution of this issue is difficult to foresee however in Texas the development of Competitive Renewable Energy Zones is the best state level initiative implemented yet when it comes to proactively build out the transmission lines.

Another possible scenario, also witnessed in Texas, is that large IPP's will build their own transmission lines such as the NextEra line.

In terms of technology development the US industry seems focused on reducing the cost of projects where the development of service and maintenance routines are becoming increasingly important as well as better siting routines. At some peak locations in the US the wind loads are much stronger than in Europe and therefore the siting standards developed in Europe are not always viable in assuring the 20 year lifetime of turbines. This leads to a need of adapting the standards and in the future also the turbines to these conditions.

From these broader issues a functional analysis was conducted according to the Innovation System Analysis framework (Bergek et al 2008) and the potential blocking an inducement mechanisms for the industry development were clustered together into the following;

Inducement Mechanisms

- Strong belief in growth potential as articulated by leading customers
- Increased investments in the supply chain
- Strong industry networks
- An increasing political and public focus

Blocking Mechanisms

- The historical and present political uncertainty
- The lack of extensive knowledge base and industry know-how
- The lack of complimentary asset

Following the identification of these mechanisms three potential business opportunities were recognized within component supply, service supply and electrical infrastructure solutions. The component supply stems from the urgent need of a domestic supply chain and within service supply there is an outspoken demand for lowering the cost of maintenance and uncertainty of who will actually provide this service. Further the opportunities within electrical components might not be in the direct future but the need is urgent and when the development starts there will be large opportunities within this area.

However there are some significant barriers of entry to overcome for a supplier wanting to move into the US. The most important one is having a proven track record in order to be recognized by the turbine manufacturers and project developers which is a critical issue for a young Swedish component supplier lacking a domestic market.

GLOSSARY

AEI Alternative Energy Institute
ARRA the American Recovery and Reinvestment Act of 2009
AWEA American Wind Energy Association
BCVD Boston Clean-Tech Venture Day
CEE Center of Energy Excellence
CERA Cambridge Energy Research Association
CFD Computational Fluid Dynamic
CLEAR Carbon Limits and Energy for Americas Renewal
CNN Certificate of Convenience and Necessity
CREZ competitive renewable energy zone
DOE US Department of Energy
EERE the office of Energy Efficiency and Renewable Energy
EER Emerging Energy Research
EIA Energy Information Administration
ERCOT Electric Reliability Council of Texas
FPL Florida Power and Lightning
FERC Federal Energy Regulatory Commission
GE General Electrics
GHG green house gas
HoR the House of Representative
IEC International Electrotechnical Commission
ILC Industry Life Cycle
IOU investor-owned utility
IPP independent power producer
IRP Integrated Resource Planning
ISO independent system operator
ITC investment tax credit
kWh kilo watt hour
GL Germanischer Lloyd
MEDC Michigan Economic Development Council
MISO Midwest Independent System Operator
MW mega watt
NIMBY Not In My Back Yard
NREL National Renewable Energy Laboratory
OE Office of Electricity Delivery and Energy Reliability
OEM original equipment manufacturer
O&M operations and maintenance
PLC Product Life Cycle
PUC public utility office
POU publicly owned utility
PPA power purchase agreement
PTC Production Tax Credit
R&D research and development
REC renewable energy certificate
RES Renewable Electricity Standard
RPS renewable portfolio standard
RTO regional transmission organization
UMASS University of Massachusetts
SEIA Solar Energy Industry Association

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1 Introduction

This chapter will provide an introduction to the topic of this master thesis beginning with background information of the historical position of the US energy debate and the issues of the US wind energy industry. Thereafter follows a definition of the purpose of the master thesis together with its limitations.

1.1 Background

The US has for a long time been lagging far behind Europe when it comes to pushing the environmental agenda and the world has been waiting for a change to occur. With the world's largest energy consumption, accounting for 1/5 of total world consumption in 2006 (eia.doe.gov, 25-01-2010), the potential impact of increasing the share of renewable energy and thus lowering green house gas emissions are substantial, however there are several problems clouding this development.

The US energy portfolio is mainly consistent of petroleum, coal and natural gas with less than 2%coming from renewable energy including wind (see figure 1) Historically the low energy prices has led the development of the energy portfolio and renewable energy sources have had a hard time competing with the incumbent technologies without promoting political incentives. For wind energy the most influential incumbent is natural gas and the sales of electricity generated from wind are much dependent on the price of natural gas. When natural gas prices boomed in mid 2008 a substantial increased sale of electricity from wind energy was observed.

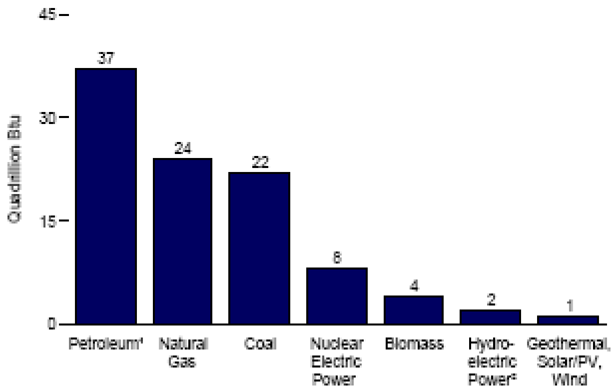


Figure 1 US energy mix, by source 2008 (*EIA, 2008*)

The price sensitivity of the US energy market makes political incentives very important but the historic unwillingness to subsidize renewable energy sources has made such energy less competitive. In Europe renewable energies have been highly subsidized and feed-in-tariffs, as implemented by Germany, is often referred to as a successful policy tool to help integrate a larger amount of renewable energy into the energy mix. The few tax incentives that have been implemented in the US, such as the Production Tax Credit, have been proven to have a substantial impact for the development of the new renewable energy projects and the industry is now advocating stronger political initiatives.

There is a lack of a sustainable policy support for renewable energies in the US which can be derived from historical reasons. The focus of energy legislation in the US have since the 70's been focused on energy independence rather than developing a renewable energy base. It was first during the beginning of the 1990's that renewable energy got any substantial space in the energy debate and later during the

Presidency of Clinton the focus was somewhat shifted to reducing green house gas (GHG) emissions. However this positive development was strongly hurt by the US withdrawal from the Kyoto Protocol done by President George W Bush after the failed ratification of the protocol by the US Congress. Later on during his presidency George W Bush did however manage to pass an Energy Independence and Security act in 2007 where a focus was put on reducing GHG emissions, fuel efficiency and increasing the minimum required levels of renewable fuels.

The difficulties of passing a strong climate legislation through the US congress still remains and the hopes that the new Obama administration brought to supporters of renewable energy have been dampened. Currently a new stricter energy legislation has managed to pass the House of Representatives but is currently stuck in the Senate where the polarization between democrats and republican have left no choice than to take forward a bipartisan approach. Such an approach will most likely not include important policy tools for renewable energy such as a federal Renewable Portfolio Standard, that would make the electrical utilities obliged to purchase a certain quota from renewable energy sources.

State initiatives have come to play an increasingly important role in the development of wind energy in the US, especially important are the states' Renewable Portfolio Standards. The potential from large abundant wind resources in the US together with state initiatives have attracted large European actors. During the years 2005-2009 the market boomed and the US has now got the largest amount of installed wind capacity worldwide. The fact that the majority of the turbine manufacturers are European and have their supply chain in Europe causes long lead times and huge bottlenecks. However, today most turbine manufacturers are establishing manufacturing facilities in the US and are either trying to make their European suppliers move with them or find new suppliers in the US. In some manufacturing heavy states, e.g. Michigan, the suppliers of the automotive industry have expressed interest in moving into the wind industry which could be one solution to the current shortage of suppliers.

Further since the technology development of wind turbines took place in Europe 20 years ago an elementary US knowledge base never mobilized. The lack is today starting to become of increasing concern since a need is articulated to understand the specific conditions of the US market better and to eventually adapt the technology to this.

Further the fact that the regions with the largest wind resources tend to be rural the need for transmission to more populated regions is crucial. This causes problem since the US electrical infrastructure is not only old an outdated but the lines are also very limited between the different regions and states. In order for renewable energy to be able to expand across the nation transmission lines need to be built out and that fast, wind projects are already being forced to shut down.

The change of administration in the US in early 2009 made the US renewable energy market an interesting case to investigate and the issues discussed above lay as a foundation to this master thesis. The decision of focusing on wind energy was taken together with the thesis's academic supervisor at Chalmers since it related to her research. Together with the idea of applying the theory of Innovation System, by Bergek et al (2008), as a market analysis tool this formed the initial idea of the thesis. Since the Innovation System analysis tries to capture the dynamics between industry, academia and policy it seemed suitable to apply to a young industry that is still very much dependent on policy. Further the interest of the Swedish American Chamber of Commerce, sponsor of the project, directed the focus towards finding opportunities for Swedish firms wanting to move into the US wind energy market as part of their Clean Tech Market Access Program. The research was then conducted from the office of the Swedish American Chamber of Commerce in Alexandria, VA, during the fall of 2009. Thanks to the funding received several field trips were made to e.g. Detroit, Chicago and Boston as well as industry conferences attended in Detroit and Orlando in order to strengthen the research.

1.2 Purpose

The objective of the thesis is to investigate the future development of the wind industry in the US. This research will be conducted through an innovation system perspective with the purpose of identifying the driving and the blocking forces.

The identified forces from the Innovation System analysis will provide a basis for the identification of opportunities for Swedish component and service suppliers. Factors that are of importance to consider when entering the US renewable energy will further be assessed to gain a better understanding of the renewable energy market in the US.

1.2.1 Research question:

- **From an innovation system perspective; what mechanisms are hindering vs. inducing the build out of wind energy in the US?**

- **Are there opportunities for Swedish component and service suppliers to the wind energy industry and what is important to consider when entering the US wind energy market?**

1.3 Limitations

From the relatively broad purpose of the thesis some limitations have been made due to the time constraints of the project. The largest one being the exclusion of offshore wind although currently more or less nonexistent in the US the development in Europe sets a path proving that this technology will most likely become increasingly important.

Further the research will also exclude investigating other competitive renewable energy sources and their potential impact on the growth of wind energy in the US. There are e.g. substantial investments currently being made into solar energy and biomass in the US and although they may not pose as a substantial threat to the much cheaper wind energy at the moment.

The supply chain will not be investigated with remarks to supply of material and the intention of the thesis is not to study the supply chain in detail but rather look at it from a market development perspective, e.g. identifying in which areas there is a need for an extensive build out.

The thesis will neither include a detailed study of the price development of wind energy, however a shorter review of the price of wind energy in comparison to the incumbents on the US market is provided.

Some comparisons with other large markets for wind energy such as Europe, China and India will be incorporated in the text but no detailed chapters providing a larger comparison will be included.

Finally the research focuses on some geographical areas in the US, mainly Texas, the mid west including Iowa and the north eastern states. These were chosen due to their recent expansion, their potential wind resource and the presence of strong industry networks. Although only one region, Texas, is presented in detail examples from the other regions will be incorporated in the text at various places. The reason why an historically important state such as California is not included in the research is due to the fact that lately the development of projects have more or less stood still and the industry seems not to be very expansive at the moment in this area. Further the states Oregon and Washington will not either be included due to the fact that they are partly focusing their future efforts on offshore wind which thus is outside of the scope of this master thesis.

2 Theoretical Framework

This chapter is divided into three sections where the first one describes the theory of Innovation System and the functional analysis that forms the basis of the analysis. The second part introduces the concept of the Industry Life Cycle in order to be able to define the maturity of the industry. Finally a discussion of different management theories is presented with the purpose to facilitate the evaluation of business opportunities.

2.1 Introduction to the Innovation System

The focus of this chapter is to introduce the concept of Innovation System (IS) and describe how it can be assessed with the help of a functional analysis. The functional analysis is described based on that developed by Bergek et al 2008 in the article "Analyzing the functional dynamics of technological ISs: A scheme of analysis", also some input from Hekkert et al, 2007 "Functions of ISs: A new approach for analyzing technological change" is presented.

To create sustainable technological development and economic growth there is a need and interest to influence speed and direction of technology change in our societies. The IS approach helps understand and assess technological change (Hekkert et al, 2007) industrial transformation and economic growth as well as the forces underlying these processes (Bergek et al, 2008). The IS analysis is increasingly recognized by both academia and the policy community as a tool to assess the effectiveness of policy programs and the forces that influence the development, diffusion and utilization of new products and processes.

According to Bergek et al, (2008) the structure of the IS consists of three major components; actors, networks and institutions. When studying a specific technology development all of those components that are directly or indirectly, intentionally or not intentionally affecting the development process should be taken into consideration. (Bergek et al, 2008, Hekkert et al, 2007) In this sense when wanting to influence a technology development parameters beyond technical change alone needs to be considered, these parameters may according to Hekkert et al (2007) be regarding social dimension and industrial networks e.g. user practices and regulations.

2.1.1 The Scheme of Analysis

The Bergek et al (2008) scheme of analysis was developed to assess the performance of an IS. The framework consists of six steps outlined in figure 2, where the two first steps describe the structure of the system including; defining the system and identifying its components.

First step, when defining the system, Bergek et al (2008) present three choices that the analyst must make:

1) Choice between having a knowledge field or a product in focus
2) Choice between breadth and depth, i.e. level of aggregation of the study, including much to get a broad picture or having a narrow focus to be more into details
3) Choice of spatial domain i.e. geographical limitations, however despite regional limitations a strong international awareness must be kept since the local IS is strongly affected by the global IS.

Second step, the structural components (actors, networks and institutions) that should be included in the IS are dependent on these three choices;

- Actors may be firms along the whole value chain and other types of organizations such as universities, industry organizations, bridging organization, governmental bodies etc (Jacobsson, 07-11-2008).

- Networks are formed as cooperative relationships among actors who can achieve complementary benefits by integrating their functional specialization and may include buyer-seller and university-industry relations. (Bergek et al, 2008) These networks can either be formal or informal (Van de Ven, 1993).

- Institutions are defined by policy and regulatory frameworks, cultures and beliefs (Jacobsson, 07-11-2008). They can have a great influence on industries, and the competitive advantage of the firms in that industry (Nelson, 1995).

In the third step the functional analysis begins. There are seven key processes called 'functions' that are investigated, these functions are described to have a "direct and immediate impact on the development, diffusion and use of the new technology" (Bergek et al, 2008). Hekkert et al (2007) describes these key processes as "activities that take place in a IS resulting in technological change". By investigating these seven functions the third step aims at describing what is actually going on in the IS in terms of "achieved functional pattern", the forth step assesses how well the functions are fulfilled in terms of "desired functional pattern", the fifth step then identifies mechanisms that are either *blocking* or *inducing* the market development (Bergek et al, 2008). The aim of the functional analysis is to assess to what degree the functions are currently fulfilled. The outcome, and the sixth step, of the analysis are specific key policy issues that are related to these mechanisms. Step 3 and 5 are more closely outlined below.

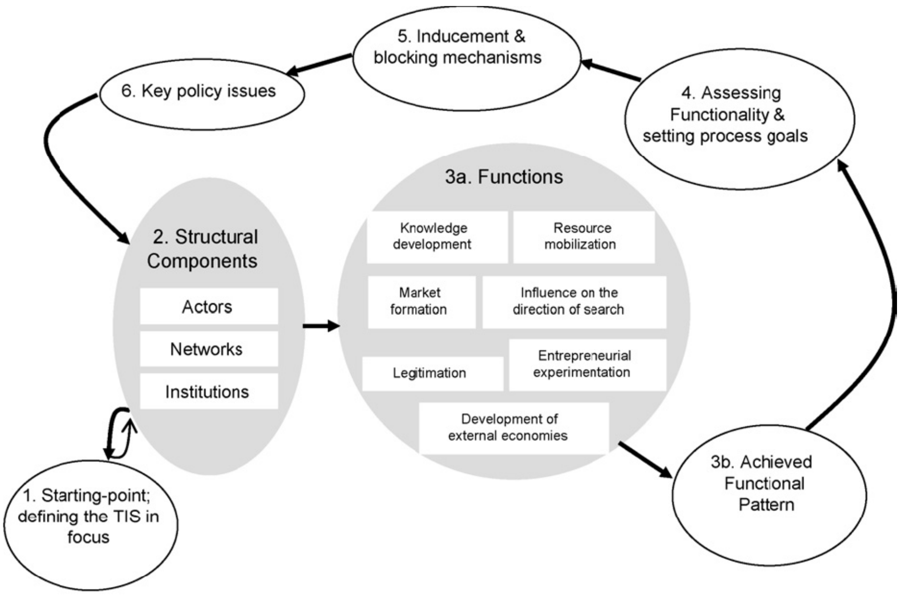


Figure 2 The Innovation System Scheme of Analysis *(Bergek et al, 2008)*

2.1.2 The functional analysis

The seven functions of Bergek et al (2008) scheme of analysis are presented below:

1. Knowledge development:

This function maps the knowledge base and the evolution of the knowledge base within the system. It also describes how knowledge is created, diffused and combined within the system. The breadth and the depth of the knowledge base are evaluated in order to identify its strengths and weaknesses.

2. Influence on the direction of search

This function identifies and assesses the incentives and drivers for actors to enter the market. It also investigates the mechanisms that guide and influence the direction of search in terms of competing technologies, business models and markets, etc. Such factors include regulatory pressure, articulated demand from leading customers, belief in growth potential, and prices.

3. Entrepreneurial Experimentation

This function investigates the number and variety of "experiments" taking place in the IS including: number of new entrants, number of different types of applications and the extent of complementary technologies employed.

4. Market Formation

In this function the drivers behind the market development are analyzed as well as the actual market development e.g. actual demand and supply. When looking at the actual market development the phase of the market e.g. nursing, bridging or mass market is assessed.

5. Legitimating

This function aims at evaluating the strength of the legitimacy of the technology and the industry as well as the factors influencing the legitimacy. Further the analysis of this function includes understanding how the legitimacy influences demand and legislation.

6. Resource Mobilization

This function aims at assessing the IS's ability to mobilize various types of resources such as human capital, financial, and complementary assets such as infrastructure and services.

7. Development of Positive Externalities

This function is somewhat different from the other functions; it is not independent but works through strengthening the other functions through positive feedback loops. For examples, as new actors enter the industry some of the initial uncertainty is reduced which leads to strengthening the '*influence on direction of search*' and '*market formation*'. Larger amount of actors in the industry increases the chance of a successful legitimating process which in turn strengthens '*resource mobilization*', '*influence on direction of search*', '*market formation*' and '*entrepreneurial experimentation*'. When a broader variety of actors enter the industry the knowledgebase is enhanced and the rate of knowledge development and diffusion is increased. The effectiveness of these types of positive feedback-loops captures the *functional dynamics* of the IS and the benefits that are generated to its members.

2.1.3 Taking the maturity of the Innovation System into account

Depending on the maturity of the IS different functions within the system are more or less important, how well a function is performing should therefore be analyzed with respect to the requirements of the phase of the IS. For instance, according to Bergek et al (2008) key words in the formative phase are *experimentation* and *variety creation* which for example requires a healthy 'Entrepreneurial

Experimentation' function. Eventually if the 'Development of Positive Externalities' is successfully promoting the IS there might be a "change of gear" moving the IS into a growth phase. In order to move from a nursing market into a mass market the growth phase requires a breadth of 'entrepreneurial experimentation' to create sufficient bridging markets, the importance of the 'resource mobilization' function therefore increases.

2.1.4 Identifying Blocking and Inducement Mechanisms

The blocking and inducement mechanisms are those forces influencing the functions of the IS and thus determining the overall effectiveness of the system. These mechanisms can be derived from the strengths or weaknesses of the functions and may be found among the system's structural components (actors, networks and institutions), however they may also exist in the broader context of the system. Bergek et al (2008) gives the example of how the reaction or lack of reaction to global warming may be an inducement or blocking mechanism to many industries.

The dynamics of the IS can be evaluated by mapping the positive and negative feedback loops going from functions to structure and back. The identification of such feedback loops together with the identification of inducement and blocking mechanisms help to identify the functional patterns of an industry.

2.2 The Industry Life Cycle

This part will provide understanding to how industries evolve and what characterizes the different phases an industry passes through. It presents three views and models of the industry life cycle and how they differ in terms of division of phases and viewpoints.

A commonly referred to marketing concept is the Product Life Cycle (PLC); products are born and demand is created, sales of the product enters a growth period, maturity is reached before entering a decline phase and a similar evolutionary roadmap can be used when observing the development of an industry. There are a couple of different prominent approaches to how this can be described, three of which will be presented here, although somewhat different in structure, they all suggest the same underlying evolution and are closely interlinked with the PLC.

Klepper (1997) bases his description of Industry Life Cycles (ILC) on the PLC and divides it into three stages, commencing with an initial, exploratory or embryonic stage followed by a growth phase and finally a third mature phase. In the embryonic stage the industry is characterized by low market volumes, high uncertainty, primitive product design and unspecialized manufacturing procedures. As the industry moves into the growth stage the product design stabilizes, manufacturing specializes and there is often a shakeout of firms as a dominant design is introduced. Finally in the mature phase the output growth slows down and the market continues to grow at a regular predictable rate, entry declines further and the market shares stabilizes. Management, marketing and manufacturing become more refined and there are few significant innovations. (Klepper, 1997)

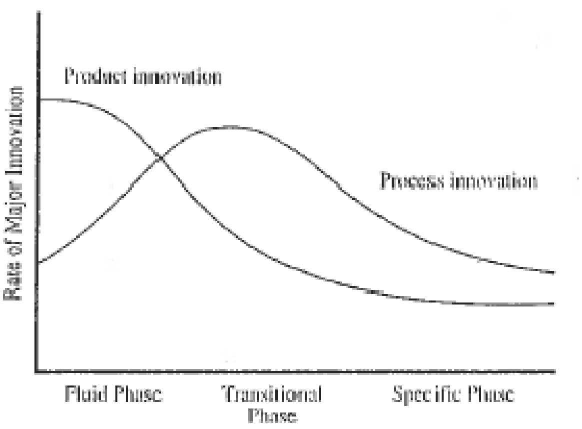
Grant (2008) further describes the ILC from a supply side perspective with similar phases as the PLC, the main difference being that the extent of an ILC is likely to be longer than the extent of the PLC due the fact that an industry produces a whole range of products. The ILC according to Grant (2008) consists of four stages; introduction, growth, maturity and decline, and identifies the most important driving forces behind this evolution to be increased demand and the creation and diffusion of knowledge. The stages are more or less coherent with those of Klepper (1997) with the added observation that as the industry becomes challenged by new industries, supplying superior substitute products, the industry enters into its decline stage(Grant, 2008).

Utterback and Abernathy (1974) also created a similar model to be able to explain the Dynamic process of innovation. They investigated the relationships between innovation, competitive strategy and state of process development and did so by separating two complimentary lines of inquiry

- Product innovations, concerned with the relationships between the firms competitive environment and the objective underlying the patterns of innovation it undertakes.
- Process Innovations, focuses on the relationship between the development of a firm's production process characteristics and the type of innovative activity it undertakes

(Utterback and Abernathy, 1974)

This original model divided the two lines, product and process innovation, into different stages of development. Process development was divided into the stages uncoordinated, segmental and systematic and Product innovation was divided into performance maximizing, sales maximizing and cost minimizing. However the model most commonly referred to as Utteback's model of the dynamics of Innovation later described three stages for both product and process innovations: the fluid phase, the transitional phase and the Specific phase (Utterback, 1994) See graph below,



Product	From high variety, to dominant design, to incremental innovation on standardized products
Processes	Manufacturing progresses from heavy reliance on skilled labor and general-purpose equipment to specialized equipment tended by low-skilled labor
Organizations	From entrepreneurial *organic* firm to hierarchical *mechanistic* firm with defined tasks and procedures and few rewards for radical innovation
Market	From fragmented and unstable with diverse products and rapid feedback to commodity-like with largely undifferentiated products
Competition	From many small firms with unique products to an oligopoly of firms with similar products

Figure 3 Utterback's Dynamics of Innovation (*Utterback 1994)*

The fluid phase is a stage of high uncertainty, and for product innovation this uncertainty stems from both target and technical uncertainty. Target uncertainty corresponds to the fact that for most early innovations there are no established markets technical uncertainty results from the diffused focus of research and development during this phase. When it comes to process innovation during the fluid phase it often takes a back seat to product innovation. (Utterback, 1994)

The transitional phase occurs when and if the market for a new product grows. The acceptance of dominant design drives the competitive emphasis in this phase to producing products for more specific users as the need of these users become more clearly understood. Product and process innovation start to be more tightly linked as focus shifts from inventor to factory. The growing rigidity of this phase means that the changes in product can only occur at an increasing cost. (Utterback, 1994)

Finally the specific phase refers to the fact that manufacturing at this stage produces a very specific product at a very high level of efficiency. The ratio quality to cost becomes the basis of competition and the linkages between product and process innovation is now extremely close, implying that any small changes in either product or process is likely to be difficult and expensive. (Utterback, 1994)

Concluding Utterback's (1994) phases much correspond to Klepper's (1997) & Grant's (2008) view of the ILC except for the fact that the model makes a separation between product and process innovation. Grant, although not evaluating them both separately, highlights the fact that after a dominant design has emerged the focus in general shifts from production innovation to process innovation.

2.3 International Business Strategy

This part of the theoretical framework will briefly touch upon the basic view on business strategies and some general implications for firms wanting to compete in an international environment. It will provide insight into the views on positioning, competitive advantage, comparative advantage and the internationalization of industries.

2.3.1 Business Strategy – two views

There are two fundamental basic views on business strategy, the positioning perspective and the resource based view. The positioning perspective is based on the Porter's five force model, analyzing the competition from the five forces identified by Porter (1980) as being; the bargaining power of suppliers, the bargaining power of buyers, the threat of new entrants, the threat of substitutes and the internal industry rivalry. The two basic strategically important issues that this analysis helps answer are, according to Jacobsson (01-10-2008);

- *Are there structural conditions favorable with respect to the sustained profitability? (industry attractiveness)*
- *What trends can we discern which affect the structural conditions, and by implication, the attractiveness of a position?*

Further the resource based view addresses the importance of the firm's own resources and capabilities. These resource can be viewed as the firm's own competitive advantage and a strategy can then be implemented which best exploit these relative the external opportunities.(Grant, 1991) Strategic issues of concern within this view are (Jacobsson, 01-10-2008)

- *Which resources and capabilities are at the heart of the firm's competitive advantage?*
- *Are these unique, difficult to imitate and sustainable?*
- *Can these be used more efficiently and to meet new market needs (i.e. diversify)?*
- *How shall we renew our resource base and capabilities?*
- *Which resources/capabilities shall we avoid or use when we diversify (core competencies and core rigidities)?*

2.3.2 Additional concerns on business strategy from an internationalization perspective

From a positioning point of view internationalization increases the internal rivalry in three different ways according to Grant (2008). First of all it lowers the seller concentration, typically more suppliers are competing on each market and thus the global market share of each firm declines as a result of national producers entering the global market. There is further also an increasing diversity of competitors that implies differences in goals and strategies etc., promoting competition but also making cooperation more difficult. Finally there is an increased excess capacity associated with internationalization. Also important is the increasing bargaining power of buyers, large customers can far more effectively exercise their bargaining power since global sourcing provides an important tool for cost reduction.

When understanding a firm's competitive advantage in an international context, the potential of a firm's competitive advantage does not only depend on its internal capabilities but also on the national environment, in the fig below the influences on a firms competitive advantage in an international context is shown;

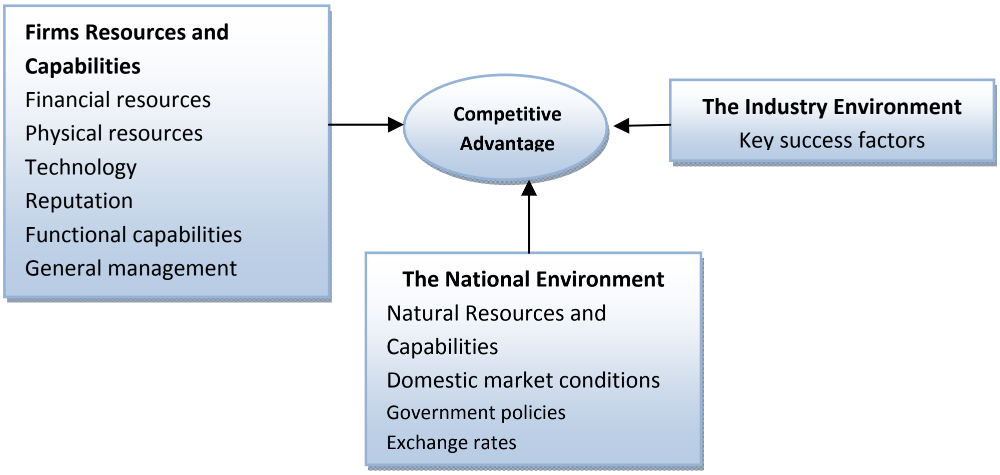


Figure 4 Competitive Advantage in an international context ***(Grant, 2008)***

The theory of comparative advantage further has an impact on strategic decision. The theory states that a country has a competitive advantage in those products that make use of the country's abundant resources. The term comparative advantage refers to the relative efficiency of a country producing a certain product. As long as the exchanges rates are stable the comparative advantage translates into a competitive advantage. Initially the theory emphasized the role of natural resources, labor and capital however now a shift in focus has put the role of knowledge and the resources needed to commercialize knowledge in center. (Grant, 2008)

Establishing a competitive advantage in a global industry thus requires matching business strategy with the countries comparative advantage. (Grant, 2008)

3 Method

The following chapter refers to the method and theory used in order to fulfill the objectives of the thesis. The structure of the method corresponds to the order of the research questions and the outline of the report. The chapter will start by providing an overview of the overall structure, through figure 5, and thereafter follow the steps outlined by this overview.

3.1 Overall method of the thesis

This section describes how the method was designed and how it helps to answer the two research questions.

The two research questions of the thesis are connected in the way that the answer to the second question is based on the outcome of the first question. To answer the first question the scheme of analysis by Bergek et al (2008), described in the previous chapter, is used to identify the blocking and inducement mechanisms of the industry.

The answer to the second research question is then derived from the idea of interpreting the outcome of the functional analysis as business opportunities instead of critical policy issues as the theory by Bergek et al (2008) suggests. This assumption is based on Hekkert et al (2007) who state that some of the key issues in many innovation policy programs are to guide technological development, spur innovation and promote economic growth. From a business perspective these three topics; technological development, innovation and economic growth, are some of the key elements of what is driving business opportunities (Grant, 2008).

As part of the second research question the opportunities identified are assessed according to their attractiveness. To further elaborate on how Swedish component and service suppliers can catch these opportunities considerations for entry strategies are discussed.

The figure below presents an overview of the method of this thesis.

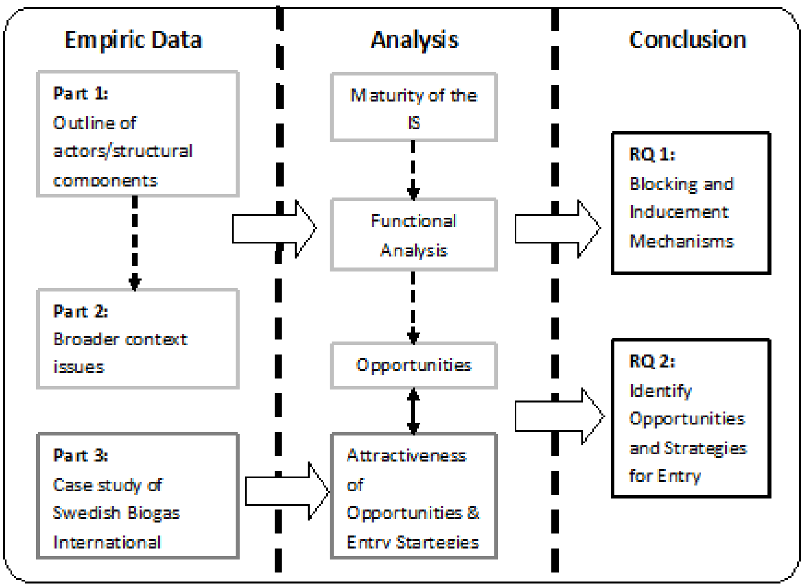


Figure 5 Model over the thesis method

3.2 Innovation System analysis

This section outlines how the IS analysis was carried out and includes the definition of the IS.

3.2.1 Defining the innovation system

The definition of the IS was done according to the theory and the thesis's limitations. The limitations were defined in the early phase of the research by discussing with actors involved in the industry regarding their perceptions of the most important areas. Concurrently industry conferences and events were attended and reports and newsletters were studied.

As a result of this initial analysis the IS was defined. Firstly the wind turbine as a product was chosen focusing on onshore utility scale turbines. Secondly the choice of having a broad focus was made in order to cover a wide range of potential opportunities within the industry. Thirdly the most important wind regions in the US were chosen as the spatial domain of the IS, however, the west coast regions were excluded. This initial data was found on the American Wind Energy Association (AWEA) webpage (awea.org, 19-02-2010).

Furthermore a specific focus was put on the state of Texas with the purpose to present a picture of a successful example of industry growth in the US and how it was achieved. This case provides insight in most issues related to the US wind industry and is therefore analyzed as an indicator of what the rest of the industry is facing.

3.2.2 Identifying the structural components

Identification of the structural components was done in a similar manner as when defining the IS, these are presented in the Empiric Chapter – Part I. With a broad focus, actors throughout the whole value chain were included with an extra focus on turbine manufacturers, component suppliers, project developers, operation and maintenance and service companies, however the supply of materials was excluded due to time constraints. Furthermore actors in the academic sector were included as well as national R&D centers. In terms of networks both regional and national networks were included. These networks were mainly of two types; industry organizations and academic collaborations.

These actors and networks were identified partly with the help of resources on www.awea.org and by attending the industry conference Small & Community Wind Conference & Exhibition organized by AWEA in the beginning of the research period. Furthermore with the help of Viveka Wahlstedt, thesis supervisor, additional interviewees were identified and contacted. When interviewing actors they were also asked to provide info about their networks, competitors, customers and suppliers, by doing so a so called snowball effect was used for identifying additional actors (Carlson et al, 2002).

3.2.3 Identifying issues in the broader context

To better understand the underlying mechanisms affecting the functional dynamics of the IS topics additional to the structural components are presented in the Empiric chapter – Part II, these are; policy, technology development, cost of technology, project financing, electricity infrastructure and competition from incumbents. These are related to the broader context of the system and were identified in the same manner as the structural components in the early research phase. The data used to describe these topics is based upon the same types of sources as for the structural components.

3.2.4 Functional analysis

The results presented in the empiric chapter laid the foundation of the functional analysis. The functional analysis was carried out according to theory by Bergek et al (2008) where the strengths and the weaknesses in the IS were later identified as inducement or blocking mechanisms. The results of this analysis provide answer to the first research question. This result together with the knowledge and insights gained during the research period laid the base for the analysis of the second research question.

Bergek et al (2008) emphasis the importance of understanding the phase of the IS and how it is influenced by the functions. Therefore the analysis chapter begins with an assessment of the industry's current stage in the industry life cycle. The functional analysis is later summarized and assessed according to the industry's different stages of development to better understand the influence from different functions in different stages. This assessment leads the analysis into the identification of the industry's current inducement and blocking mechanisms.

3.2.5 Case Study of Swedish Biogas International

The second research question contains a follow up question where key success factors when entering the US clean-tech market are evaluated. To provide more insight into this matter a case study of Swedish Biogas International LLC, a Swedish company that produces biogas, was conducted. This company was chosen since it represents a success story of a Swedish clean-tech firm moving in to the US market, and no similar case of a Swedish clean-tech company entering the US wind industry could be found. Secondly the challenges and success factors of the Swedish Biogas International case would not significantly vary dependent on if it is a clean-tech company in general or if it is a wind company.

3.2.6 Means of collecting data and sources of data

Since the thesis aims at creating a *broad* understanding of the potential opportunities that may exist within the industry, the research was conducted at a rather aggregated level. In addition this explains why no quantitative research was conducted during the assessment of the different functions e.g. in the 'Resource Mobilization function' the number of new entrants could have been assessed as suggested by Bergek et al (2008). The only quantitative data used was collected market data from industry reports regarding market shares, installed capacity and growth rates.

Instead the research approach was qualitative where the bulk of the findings were based on interviews with the following three types of actors:

1) Industry actors from the parts of the supply chain chosen to study; turbine manufactures, component and service suppliers and project developers
2) Industry experts, e.g. industry research consultants and regular business consultants, regional business developers
3) People involved with regulatory institutions on both a state level and a federal level

The interviews have been conducted in a semi-structured way where an interview guide was prepared and used for each type of actor (Bryman and Bell, 2007). However since a flexible interview approach was used additional room was left for questions and reflections not included in the interview guide (Bryman and Bell, 2007).

A second important source of information was from seminars attended at industry conferences and other events. Two types of events were attended;

1) Industry conferences organized by AWEA; Small & Community Wind Conference & Exhibition, AWEA Wind Energy Fall Symposium

2) Clean tech events: Transatlantic Solutions for a Low Carbon Economy organized by Heinrich Böll Stiftung, Boston Clean-tech Venture Day organized by SACC-New England

The information provided during the seminars was transcripted and later used as a base when formulating interview guides (see appendix 3) and as input for the functional analysis.

Regarding the specific case study of Swedish Biogas International the company was identified through the network of SACC-USA and the study was conducted through qualitative interviews with;

- Consul General Lennart Johansson of Detroit
- The CEO of Swedish Biogas International, Tomas Guise.

Further through another master thesis student, Christina Andersson from KTH, a survey regarding Swedish Biogas International's networks was provided.

To complement the information from Swedish Biogas International regarding key success factors the Boston Clean Tech Venture day was attended and further interviews were conducted. These interviewees included Doug Faulkner, President Chrysalis Energy Partner, and Ross Harding, Partner at Energy Launch Partners LLC.

4 Empiric chapter - Part I

The Empiric chapter is divided into three parts; Part I begins with an overview of the market growth, it then continues with presenting the various actors in the Innovation System. From these actors' experiences the next section, Part II will highlight the most important ones, such as policy, transmission, technology development and competition from incumbents. All of the previously mentioned topics will later be applied to the specific case of Texas, part of Part III, where the special Swedish Biogas International LLC case is also presented.

4.1 Industry Growth

In this chapter the reader will be presented with an overview of the growth of installed capacity over the last decade and how the growth varies between different states.

4.1.1 Growth of installed capacity in the US

The US wind energy industry has during the latter half of the last decade experienced extraordinary growth. During the years 2006-2008 the country accounted for the highest global share of annual installed capacity establishing the US together with China and India as one of the leading global markets for wind development (BTM, 2009a). In terms of actual growth rate during the years 2005-2008, China takes the lead with a rate of 112%, France comes second with 68% and US comes third with 40%, for the top ten countries the average growth rate has been 26.6% (BTM, 2009a).

In 2008 the US market culminated as a total of 8,500 MW were installed in during one year which enabled US to surpass Germany and become the world leader in terms of installed capacity (AWEA, 2008). In 2009 due to the economic downturn the rate of installed capacity was expected to slow down somewhat, however in reality the opposite happened as 9,900 MW was installed which exceeded the record year of 2008. The total cumulated base of installed capacity in the US has now reached 35,159 MW. (AWEA, 2010) The federal stimulus bill passed in February 2009 which extended the Production Tax Credits (PTC) and provided alternative funding incentives such as the Investment Tax Credits (ITC) and cash grants is considered to be one of major factors for the continued growth in 2009 (AWEA, 2010).

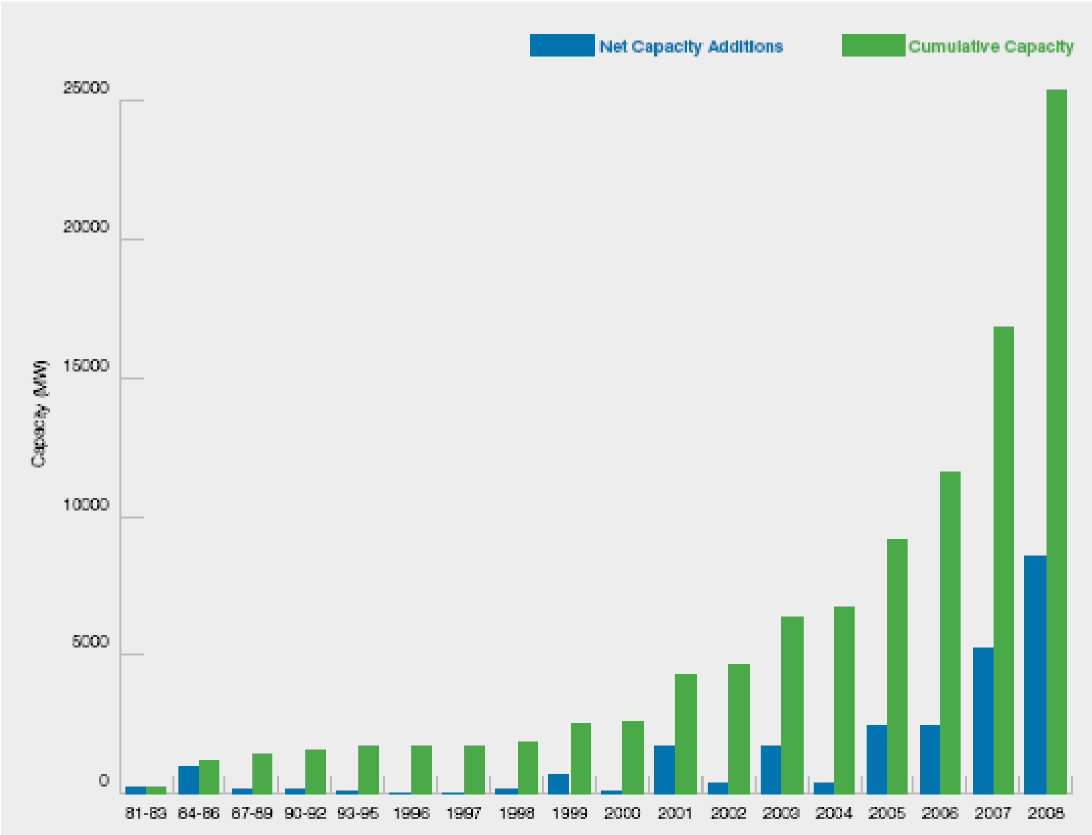


Figure 6 Overview of Market Growth (AWEA, 2009)

4.1.2 Growth of installed capacity by state

The amount of installed capacity varies widely between states as can be seen in figure 7 below. There are currently 36 states with utility-scale wind farms and fourteen states with more than 1000 MW installed capacity. Texas is by far the leading state with more than 9000 MW installed, second comes Iowa and third California. The states where most capacity was installed in 2009 were Texas, Indiana, Iowa, Oregon and Illinois. Despite California's large installed base the state has not experienced much growth during the last couple of years. (AWEA, 2010)

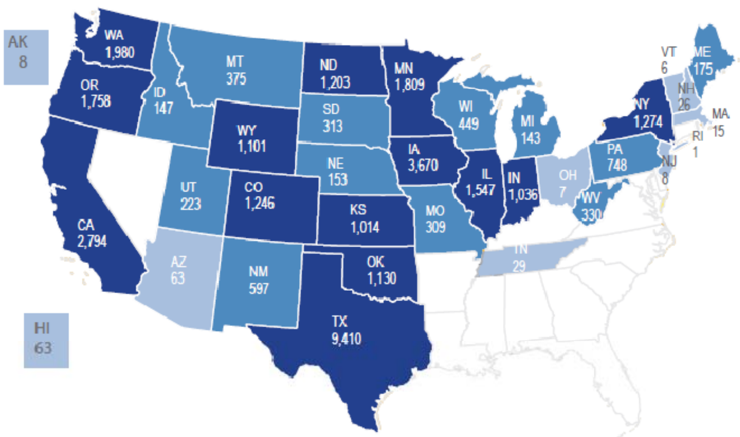


Figure 7, Cumulated installed capacity by state *(AWEA, 2010)*

There are a number of attributes that affects the level of development within a state. To begin the state's wind potential is obviously one of the most important fundamentals table 1 below provides a list of the 25 states with the highest potential. Secondly the access to transmission is crucial, especially for those rural states located far from the heaviest load areas; this issue is further discussed in chapter 5.2. Thirdly the political aspect is a strong factor and along with increased political interest states with a RPS in place have experienced significantly stronger growth (Barbose et al, 2007). Furthermore interviews with project developers showed that specific state characteristics such as number of landowners, permitting and siting processes, property taxes and public acceptance have a strong impact on where project developers decide to locate.

Table 1 List of Wind potential by State ***(www.awea.org, 25-01-2010)***

1	**North Dakota**	**9**	**Minnesota**	**17**	**California**
2	Texas	**10**	Iowa	**18**	Wisconsin
3	Kansas	**11**	Colorado	**19**	Maine
4	South Dakota	**12**	New Mexico	**20**	Missouri
5	Montana	**13**	Idaho	**21**	Nevada
6	Nebraska	**14**	Michigan	**22**	Pennsylvania
7	Wyoming	**15**	New York	**23**	Oregon
8	Oklahoma	**16**	Illinois	**24**	Washington
				25	Massachustes

4.2 Overview of the Supply chain and the Industry Actors

This chapter will first present an overview of the industry's supply chain and, it will then go into detail about four parts of the supply chain including the actors involved in those parts; however the supply of material is excluded in accordance with the limitation of the thesis. The chapter will present the stage of development and the challenges that the each type of actors face.

4.2.1 The scope of the supply chain

The scope of the supply chain reaches from supply of materials to operation, service and maintenance as seen in figure 8 below.

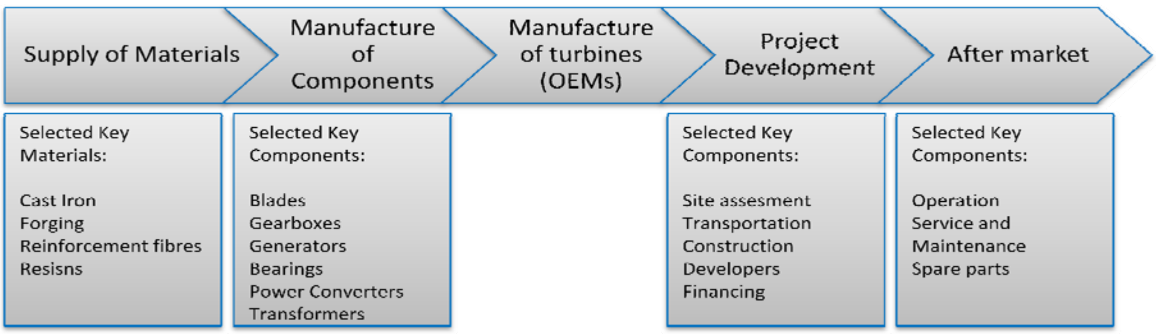


Figure 8 Overview of the Supply Chain ***(BTM, 2009a)***

Globally, the supply side rather than the demand side has historically determined the growth of the global wind industry, this stems from the situation prior to 2007 when a majority of key components were sourced from Europe. Since then new manufacturing capacity has been established around the world, especially in Asia (BTM, 2009b).

However, due to uncertainty regarding the future scale of the US wind industry both US and foreign firms have historically shown limited interest in investing in domestic turbine and component manufacturing. A domestic supply chain have thus never been fully developed which has left the industry heavy reliant on import. According to Umanoff (18-12-2009), lawyer at Chadbourne & Parks, a difference seems to have come in 2007 when most of the world's leading turbine manufacturers had either established manufacturing facilities in the country, or announced that they were going to do so and as a consequence component suppliers dared to follow their customers, however turbine manufacturers are still sourcing a vast majority of components from abroad. Interviews with actors throughout the supply chain and information from industry seminars show that the situation is unsatisfying and there is a push for a further development of the domestic supply chain. Nordex's supply chain manager simply puts it this way during the AWEA Small & Community Wind Conference & Exhibition (03-11-09) *"If you aim at building local manufacturing it's natural to want a local supply chain as well"*.

4.2.2 Turbine Manufactures

The global wind turbine market is fairly consolidated with the Top 10 companies covering over 84% of the world's demand in 2008, however this figure was higher in 2007 but with an increase in market share by smaller actors, mainly Chinese, the figure decreased in 2008 (BTM, 2009b). Further the turbine market has been characterized by several large acquisitions that can be seen in table 2 below.

Table 2 List of major Acquisitions during 2000's (Information taken from OEM's web-pages)

2002	Gamesa acquired Made
2002	GE Wind acquired Enron Wind Corporation
2003	Vestas merged with NEC Micon
2005	Siemens acquired Bonus
2006	Suzlon acquired REpower
2009	Daewoo acquired DeWind

Vestas is dominating the global market with a share of almost 30% in 2008, GE Wind comes second globally but is by far the leading supplier in the US market, which is also its home market, with a market share of 55% in 2008 (BTM, 2009a). The US Top 8 suppliers accounted for over 98% of new installations in 2008 which makes the US market, like the global market, fairly consolidated, however each year new companies enter the market. According to AWEA, as of November 2009, nine original equipment manufacturers (OEMs) are operating turbine manufacturing and assembly facilities in the US; Acciona, Clipper, DeWind, Gamesa, GE, Nordic, Siemens, Suzlon, Vestas, and six additional OEMs have announced plans on opening manufacturing facilities in the US (awea.org, 10-02-2010), most of these actors are European with the exception of GE, Clipper and Nordic which are American.

Among the turbine manufacturers that have announced or already have established manufacturing facilities in the US there are several smaller companies. These include Fuhrlander, who will open a turbine assembly plant in Butte MT, Nordic Windpower who will open a turbine manufacturing and assembly facility in Pocatello ID and Emergya Wind Technologies who is building two new manufacturing facilities in Little Rock AR. (EERE, 2009) Furthermore Northern Power Systems, a US company based in Barre VT, who manufactures a 100 kW direct-drive turbine, re-organized its business in 2008 and is planning a 2.2 MW direct-drive turbine in late 2010 and thus entering the utility scale market (northernpower.com, 03-02-2010). Nordex, a larger European actor, installed its first turbine in the US during 2009 are in the process of establishing a blades plant and a nacelle assembly plant in 2012, in Joesbro AK (Sigrits, 25-11-2009).

The figure below shows the installed capacity in 2008 and 2009 by each turbine manufacturer.

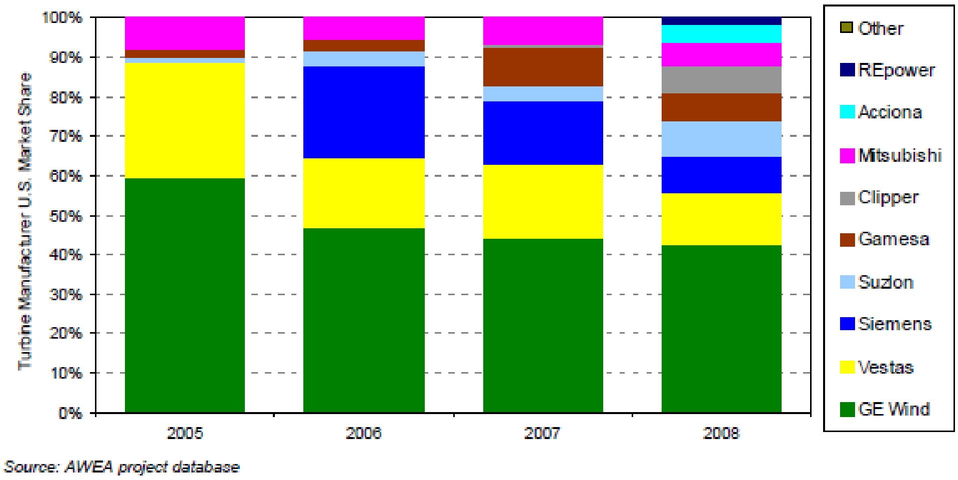


Figure 9 Annual share of installed capacity by turbine manufacturer *(EERE, 2009)*

4.2.2.1 Barriers to entry

One of the turbine industry's strongest barriers to entry is the need for a proven technology and operating track record. Interviews with project developers and industry consultants show that this tendency grows stronger as investors become increasingly experienced and puts higher demands on performance of projects. Furthermore, according to turbine manufacturers, the US market is more price competitive than the European market due to the country's low price of electricity which further raises the barriers to entry for small actors who cannot benefit from scale advantages.

Furthermore there is an increasing push from Asian actors to join the turbine industry. This is likely to spur the price competition further as many of them can benefit from cheap manufacturing, a strong home market and the financial resources to acquire new technology. Asian conglomerates that have recently entered the field are Hyundai, Samsung and Daewoo Shipbuilding and all of these actors sees the US market as an important future market (BTM, 2009a).

Table 3 Challenges acknowledge by OEM's

Largest challenges acknowledged by OEMs during interviews and industry conferences:

- Decrease in demand due to difficulty in finding project financing
- Decreased electricity demand and low natural gas prices
- Need for know-how and trained resources
- Uncertainty regarding US energy policy
- Gaining public acceptance
- Threat from Asian actors
- Little recognition of safety issues within the industry

4.2.3 Component suppliers

In 2007 and 2008 the lack of a proper domestic supply chain in the US, in combination with extraordinary growth, led to a significant shortage of supply of most key components. In addition, interviews with suppliers showed that poor communication between project developers, turbine manufacturer and component suppliers made the supply chain inefficient which further contributed to the shortage.

According to interviews with turbine manufacturers the availability of material and components has significantly improved during the recent slowdown of the economy, further, according to AWEA (2010) much of the demand in 2009 could be satisfied by high inventories. This seems to have given the US supply chain a chance to recuperate and has allowed its actors to reorganize. The importance of good supplier relationships therefore seems to have increased and many turbine manufacturers expressed their wish to build long term strategic relationships with key suppliers in the US market during a recent industry conference. This trend is, according to BTM Consult (2009a), also dependent on the industry development towards more specialized design of turbine components which requires stronger relationships with key suppliers. However, to avoid bottlenecks the turbine manufacturers express the importance of not being dependent on a single supplier and they encourage their suppliers to avoid it.

4.2.3.1 Degree of vertical integration

The wind industry is considered to be characterized by a high degree of vertical integration and this trend is estimated to continue according to a global supply chain assessment made by BTM Consult (2009a). As seen in the global overview presented in table 3 most of the turbine manufacturers source key components in-house, Siemens, Suzlon and Gamesa are the most vertically integrated of the companies present in the US and GE the least. Although there seems to be a trend towards more in-house sourcing some turbine manufacturer says that they see little linkage between increased profit and in-house sourcing.

Today most of the major turbine manufacturers have established, or are in the process of establishing, manufacturing facilities of components in the US. Such components include blades, nacelles and towers however a majority of other key components, e.g. gearboxes, must be sourced from abroad. The turbine manufacturers' major concerns with foreign supply, expressed during interviews and industry seminars, are costs associated with long lead time, transportation and exchange rates, and quality risks associated with transportation.

Regarding blades a majority of the turbine manufacturers either source their blades in-house and or sources them from LM Glasfiber who is the world leading blade supplier (BTM, 2009a). The quality of the blades is very important in terms of cost control and reputation, to be able to monitor the quality most turbine manufacturer have established domestic blade manufacturing facilities.

The gearbox is the key component with one of the highest failure rates in addition, most gearboxes are sourced from Europe which poses problems with long lead times for reparations. Gearboxes, and large bearings used in gearboxes, caused the major shortages in the supply chain during 2007-2008 and the supply of those components is likely to continue to be under pressure (BTM, 2009b). Manufacturing capacity has increased in China (BTM, 2009a) but the turbine manufacturers in the US are asking for more local options. To overcome gearbox issues several turbine manufacturer are sourcing some of its gearboxes in-house such as Gamesa and GE through their subsidiaries Echesa and GE Transportation. Further Siemens recently acquired gearbox manufacturer Winergy and Suzlon did the same with

Hansen Transmission. Vestas, Nordex and Acciona do not at the moment have that capacity. (BTM, 2009a)

Large bearings are estimated to continue to be a main bottleneck within the industry, the component is complex and in 2008 only 30-40% of potential suppliers were estimated to be able to reach the standards required in a wind turbines, which further contribute to the shortage (BTM, 2009a) The most important factor when assessing the supply of bearings is therefore not so much the manufacturing capacity as the quality level. SKF and Schaeffer are stretching their limits to supply the industry worldwide (BTM, 2009a) and SKF have one factory in Hannover PA partly dedicated to the wind industry and are collaborating with some of the large turbine manufacturers (Nielsen, 27-10-2009). However the OEM's wish for more dedicated investments from the bearing suppliers but installation of new machinery equipment takes time and is very costly (Nielsen, 27-10-2009).

The suppliers of generators consist of a few large companies who produces generators as a part of their overall business e.g. ABB, and a few new suppliers from emerging markets such as China. The global supply of standard generators is expected to be enough to supply a continued growth but if the demand for more advanced application increases this situation might change (BTM, 2009a) Vestas, Siemens, Suzlon and Gamesa can source this component in-house.

Table 4 Overview of OEM's sourcing strategies ***(BTM, 2009a, web-pages of OEM's)***

Turbine Manufacturer	Blade	Gearboxes	Control systems	Generators	Towers	Domestic manufacturing facilities
GE	LM, Tecsis, MFG	Winergy, Bosch, Rexroth, Eickhoff, **GE Transportation**	**GE**	Loher, ABB, VEM	DMI, Omnical, SIAG	Manufacturing & Assembly: Tehachapi CA, Greenville SC Pensacola FL,(blades)
Vestas	**Vestas,** LM	Bosch Rexroth, Hansen, Winergy, Moventas	Costas **(Vestas)**, NEG (Dancontrol)	Weier **(Vestas)**, Elin, ABB, LeroySomer	**Vestas,** NEG,DMI	Windsor CO (blades), Brighton CO (WTGs, blades), Pueblo CO (towers) Repair facility for gearboxes in CL
SIEMENS Siemens Wind Power GmbH	**Siemens**, LM	Winergy **(Siemens)**	**Siemens**, KK electronic	**Siemens**, ABB	Roug, KGW	Nacelles/hub manufacturing: Hutchinsons KA, Ft.Madison IO (Blades)
SUZLON	**Suzlon**	Hansen **(Suzlon),** Winergy (Siemens)	**Suzlon**, Siemens	**Suzlon**	**Suzlon**, Mita Teknik	Blades and nose cones: Pipestone MN
Gamesa	**Gamesa**, LM	**Echesa (Gamesa)**, Winergy (Siemens),Hansen (Suzlon)	**Ingelectric (Gamesa)**	**Indar (Gamesa)**, Cantarey	**Gamesa**	Fairless Hills PA (Nacelles, blades)
Clipper	Tecsis	**Clipper**	**Clipper**	Potencia	Emerson, Anston	Manufacturing: Cedar Repids IO
acciona Energy	Tecsis, LM	Moventas, Winergy	Ingeteam	Ingeteam, ABB		
NORDEX We've got the power.	**Nordex,** LM	Winergy (Siemens), Eickhoff, Maag	**Nordex**, Mita Teknik	Loher, VEM	**Nordex**, Omnical	2010 Nacelle assembly: Jonesbro, AK 2012 Blade production: Jonesbro, AK

4.2.3.2 Investments in the supply chain

According to AWEA the share of the domestically manufactured turbine value has grown from around 25% in 2005 to nearly 50% in 2009 (awea.org, 03-02-2010). However this number varies between turbine manufacturers e.g. Vestas sources around 10% domestically but aims at increasing this number during 2010-2011 (Goodwill, 18-12-2009). During 2007-2008 US turbine and component manufacturers have added or expanded over 70 facilities as seen in figure 10 below.

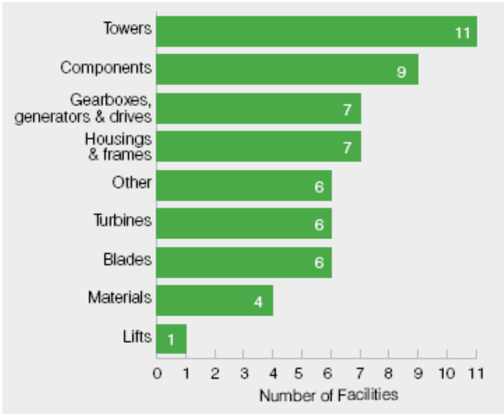


Figure 10 Number of manufacturing facilities added or expanded during 2007-2008 ***(AWEA, 2009)***

On the component side a considerable number of new manufacturing facilities were announced or opened by both foreign and domestic firms. Some of these domestic actors have transferred or branched out from adjacent industries, seven of these companies can be found in Michigan and Ohio who was hit hard by the economic downturn, e.g. E-T-M, a producer of composite parts from the automotive industry and Minster Machine Company, a manufacturer of equipment for the auto, medical, and food industries now also manufactures wind turbine hubs. Also Arkansas, who like Michigan and Ohio is geographically well positioned but has little installed capacity, saw four new announcements or openings in 2008. Manufacturing facilities were also opened or announced in states with much installed capacity; four in Texas, six in Colorado and five in Iowa. (EERE, 2009) However during 2009 the total investment in the manufacturing sector dropped compared to 2008 which might be a consequence of the economic downturn (AWEA, 2010).

4.2.3.3 Barriers to entry

Turbine manufacturers encourage the build out of a domestic supply chain however new suppliers expressed their problems with getting by the ‘gatekeepers’ at the large turbine manufacturers’ procurement departments. This topic was discussed during a supply chain seminar at the AWEA Small and Community Wind Conference & Exhibition, 2009, the turbine manufacturers’ advice to potential suppliers is to have patient, have good knowledge about the industry and be willing to make strategic investment, furthermore it’s of high importance that they can show credibility and a track record. The turbine manufacturers added that if they are not suited to be 1st tier supplier they can be recommended to the turbine manufacturers’ 2nd tier suppliers.

Since the quality of components is an important issue some industry actors express their skepticism during interviews and industry seminars towards component suppliers with a background in the automotive industry. Sources of skepticism come from the fundamental differences between wind turbines and cars such as expected run-times and strength of mechanical forces. In addition, as the turbines grow larger the manufacturers’ requirements on new technology and quality become increasingly difficult to meet which further limits the number of potential suppliers available who can keep up with the pace of development (BTM, 2009a). However, industry actors are valuing the long experiences of such companies, e.g. coming from the automotive industry, especially when it comes to documentation, service and inventory which the young wind industry could be better at.

Table 5 Challenges acknowledged by component supplier

Largest challenges acknowledged by the component suppliers and OEMs during interviews and industry conferences:

- Lack of domestic supply chain bring risks associated with cost, time and quality
- Components require increasingly higher quality and level of sophistication
- Shortage of key components is improving but will still remain a problem for some of the components
- Need for improved communication
- Identifying the right strategic relationships

4.2.4 Project developer and investors

There has been a consolidation trend among US project developers and between 2002 and 2008 around forty large acquisitions were announced (EERE, 2009). However in 2008 this trend slowed down, perhaps as a result of the economic downturn or due to the fact that most prime targets had already been acquired (EERE, 2009).

NextEra is by far the largest wind project owner in the US and owned approximately 25% in 2008 of the country's total installed base. In 2008 five other companies, besides form NextEra, had assets exceeding 1000 MW, see figure 11 (AWEA, 2009). Since the market took off in 2005 foreign companies, mainly European, have entered the US market, and in 2009 almost half of the projects being built in the US were developed by foreign companies (AWEA, 2010). Many of these companies have entered through acquisitions such as the largest foreign actor Ibedrola Renewables from Spain, E.ON Climate & Renewables from Germany and Horizon-EDP Renewables from Portugal, and BP Alternative Energy from UK (EERE, 2009).

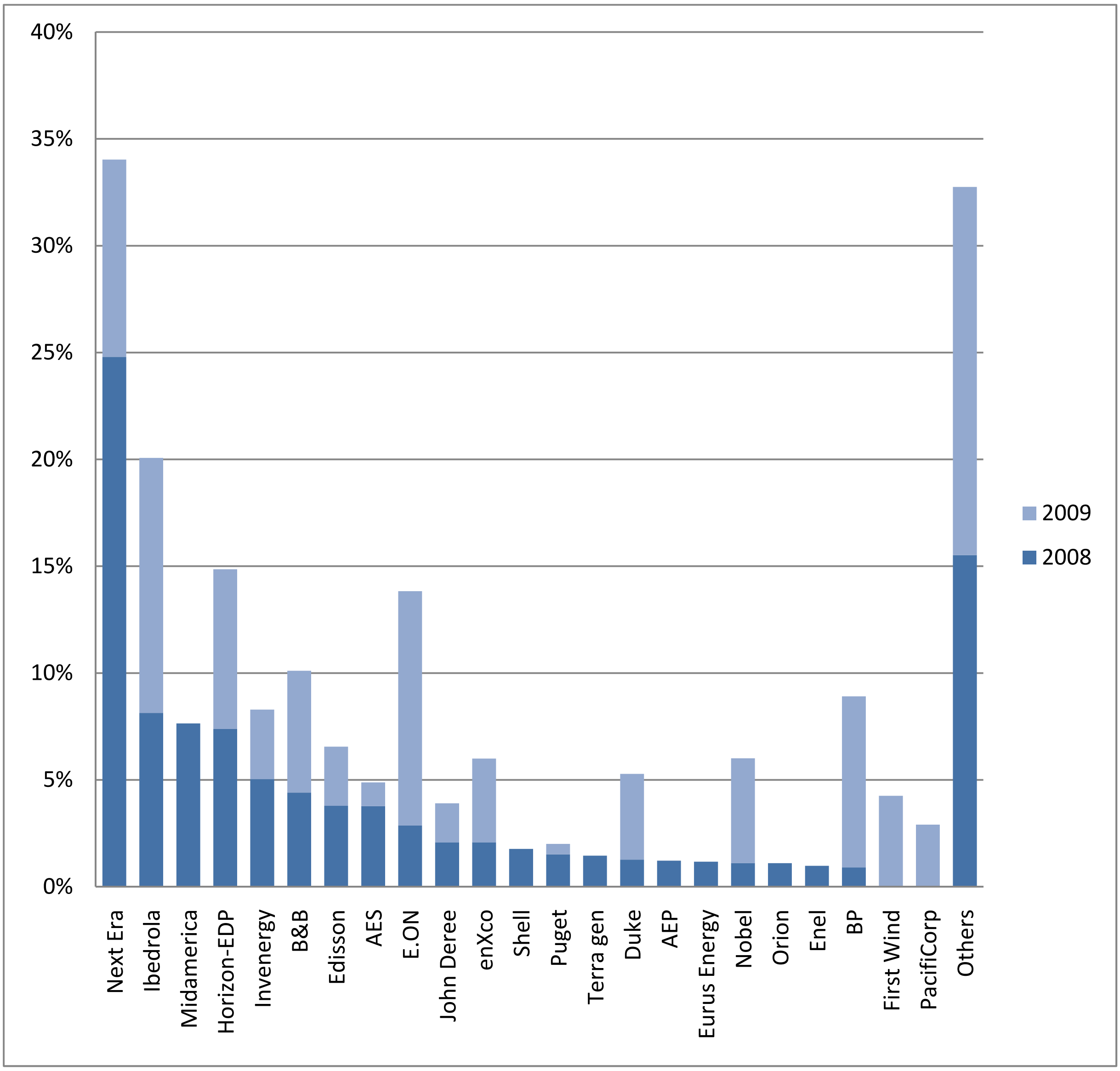


Figure 11 Developers market share, based on total annual installation, 2008-2009 ***(AWEA, 2009, AWEA 2010)***

The majority of the US project-owners are Independent Power Producers (IPP) but an increasing part of the new installed capacity is owned by utilities, see figure 12 below. Also several of these IPPs are subsidiaries of public utilities, since the public utilities' rates of return are regulated and to be able to grow the utility companies create unregulated subsidiaries (IPPs) that manage the competitive part of the business such as investing in power plants (Umanoff, 18-12-2009) An example is NextEra who is a subsidiary of FPL Energy a utility in Florida (www.nextera.com, 03-02-2010). This type of ownership structure is common since it allows the subsidiaries to benefit from the expertise and resources within the utility family however the subsidiaries are generally not allowed to invest in power plants within the region of the parent utility company (Umanoff, 18-12-2009).

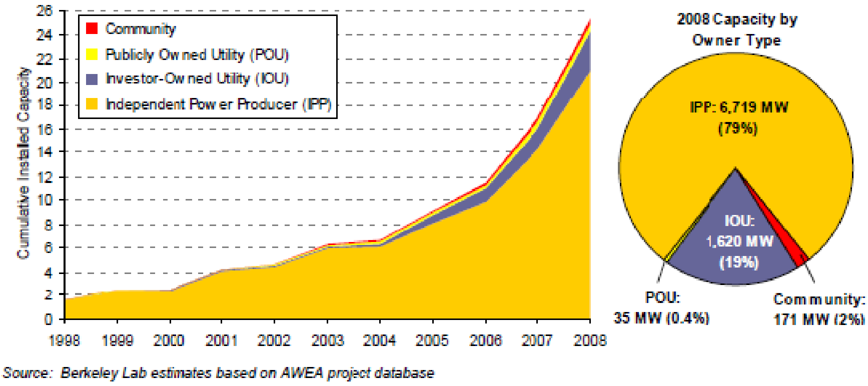


Figure 12 Cumulative and 2008 Wind Capacity Categorized by Owner Type *(EERE, 2009)*

4.2.4.1 Project sizes

The US wind industry is characterized by large sizes of wind farms and the size is continuing to increase, however in 2008 the average size was 83MW which I below the 120MW in 2007, see figure 13. Drivers for the increase in project size are according to Energy Efficiency & Renewable Energy (EERE) report, written by EERE 2009, posed by several trends such as: growing demand for wind, increased size of turbine orders that became standard practice up until the recent economic downturn, consolidation among wind project developers to support larger orders, and increasing turbine and project costs which promote capturing of opportunities of economics of scale. The size of a project may be influenced by access to capital, turbines and transmission which might explain the decrease in average size in 2008 (EERE, 2009).

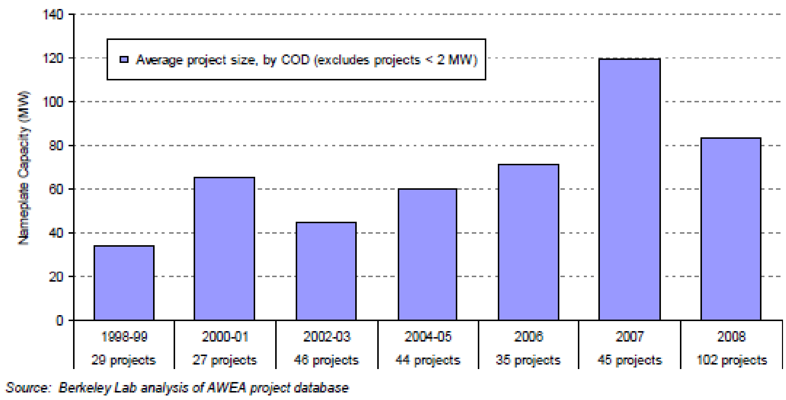


Figure 13 Average Project Size *(EERE, 2009)*

Table 6 Challenges acknowledged by project developers

Largest challenges acknowledged by the project developers during interviews and industry conferences:

- Access to transmission
- Acquiring project financing
- Unstable policy environment
- Lengthy permitting processes in some regions
- Turbine failure rates
- Supply of turbines
- Signing PPAs

4.2.5 Service suppliers and the development of O&M market

According to interviews conducted with actors throughout the supply chain, as well as with industry consultants, the majority of the US turbines are currently still under warranty by the OEM or under an OEM service contract, meaning that it is the turbine manufacturer who takes care of scheduled and unscheduled maintenance. As the warranty period will start to run out eventually there is the question to weather the majority of the project owners will take over the operation and maintenance (O&M) or if the turbine suppliers will continue. Since the US industry is still so young the aftermarket has therefore not yet been crystallized.

The research has shown some indicators of a slight reluctance of US project developers, compared to Europeans, to invest in services and maintenance. Besides from the yet underdeveloped O&M market SKF says that they are having a harder time selling their Condition Monitoring System in US compared to Europe (Karlsson, 30-09-2009) further the US operational culture is less about maintenance than the European (Ericsson, 09-09-2009). The lower interest in investing in O&M services and equipment may, according to some service suppliers, be an effect of the US wind industry's dependency on tax equity investors who are looking for more short term returns on their investments e.g. the period of ten years that the project is eligible for the production tax credit.

However there is an opposing trend as well, both Vestas and Nordex claim that their US customers are increasingly willing to pay an extra premium for longer warranty periods (Goodwill, 18-12-2009, Sigrist, 25-11-2009). Nordex for example has three different service packages (Table 7) and the CEO Ralf Sigrist (25-11-2009) puts it this way: "*When we came to the US people said we would only sell O&M contracts for up to 2-5 years but no one would ever be interested in 10 year contracts, but at the moment we estimate that 50% of our customers may be interested in the long term contracts*". In addition, according to project developers, with stronger requirements from experienced investors the turbine manufacturer's warranty track record is of high importance to the project developer when choosing supplier.

Table 7 Example of Nordex's service offer *(Sigrist, 25-11-2009)*

Service	Basic	Extended	Premium
Maintenance/ Repairs	Basic rates for materials	Basic rates for materials	Repairs and replacement parts included
Availability warranty		95% per farm	95% per farm
Condition Monitoring		Optional	Included
Technical management	Optional	Optional	Optional
Term	any	up to 6 years	up to 10 years

Vestas has experienced similar situation and says that when the warranty period or the initial service contract expires usually their customers have the intention to do maintenance themselves, still they often come back and Vestas estimates that around 95-98% of all their service contracts are renewed (Goodwill, 18-12-2009).

4.2.5.1 Impact of size of projects

Large wind farms often consist of several phases containing different brands on turbines. During the warranty period the different turbine manufacturers are performing the maintenance while the operation is often done by the project owner; this is the case at E.ONs wind farm in Roscoe TX. This wind farm is still under warranty and E.ON says that they have not yet decided whether to perform service and maintenance themselves, to source it from a third party supplier or if it is economically viable and possible to keep the individual service teams for each turbine brand (Woodson,08-12-2009). According to Vestas, owners of project with different turbine brands usually do not do their own service and maintenance due to the complexity and cost of keeping spare parts and knowledge updated for several turbine brands. Instead they usually rely on the turbine manufacturer to continue to do the service and maintenance (Goodwill, 18-12-2009). On the other hand, according to independent service suppliers, due to size large scale utility projects find it economically profitable to perform the service themselves. This is, according to industry consultants, probably true for the increasing number of utility companies owning projects since they can benefit from long experience of running power plants.

Despite uncertainties regarding structure and actors it is generally agreed upon that there is an increasing demand for O&M services. GE has made it publically known that they will put more emphasis on the service sector and both Vestas and Nordex say they will do the same (Goodwill, 18-12-2009, Sigrist, 25-11-2009) Furthermore the number of independent service suppliers is increasing, recently one of Vestas' component suppliers announced that they will make a stronger effort in entering the service field (Goodwill, 18-12-2009).

4.2.5.2 Barriers to entry

As the wind market grows the turbine manufacturers are likely to catch the opportunities on the service market which thus will make them more prone to exclude competitors such as independent suppliers. They can do so by leveraging on their advantage of having first hand access and knowledge about the technical information about their products. However, to promote their turbines they must make sure that there are enough service providers with knowledge about their turbines and therefore they need to educate and train third party suppliers.

According to project developers, when it comes to construction services is their track record equally important as warranty and quality track records are for turbine manufacturers, since the project developers must keep deadlines to avoid losing out on tax credits. Furthermore the turbine manufacturer must approve of the turbine installation contractor in order to for the warranty to be eligible (Sigrist, 25-11-2009).

4.2.5.3 Access to human capital

According to Vestas, the increasing numbers of US colleges that provide education for service technicians to the wind industry have made it fairly easy to recruit service staff. Vestas currently collaborates with the following collages: Iowa Lakes Community College, Columbia Gorge Community College, Texas State Technical College-Sweetwater and Lakeshore Technical College are acknowledged by Vestas. (Goodwill, 18-12-2009) Many of the large turbine manufacturers also have announced, or have established training centers in the US, e.g. GE, Vestas and Nordex. However both Nordex and Vestas mention the risk of losing trained staff to the project developer as the warranty period or the initial service contract runs out (Goodwill, 18-12-2009, Sigrist, 25-11-2009).

Table 8 Challenges acknowledged by service suppliers

Largest challenges acknowledged by the service suppliers, project developers and OEM's during interviews and industry conferences:

- Uncertainties regarding market shares and industry structure
- High cost of O&M services

- Access to human capital and know how

4.3 Industry Organizations

This chapter will provide a picture of the different types of interest organization that exist within the industry, focusing on the American Wind Energy Association(AWEA) and its regional partners as well as mentioning some of the movements acting against the industry.

Currently there are a lot of strong forces acting towards reforming US energy policies towards promoting greener more sustainable alternatives. The majority of these actions are currently ongoing in Washington DC, a city where interest groups and lobbying firms receive a lot of focus when it comes to changing the legal structure. Many of these firms submit recommendations or lobby at congressional hearings and thus have a relatively strong influence over lawmakers. Some of the promoters of renewable energy in the US include “The union of concerned scientist”, “The Energy Foundation” and “Climate Works”.

However for wind energy the strongest advocate is the American Wind Energy Association (AWEA). The mission of the organization is to promote the growth of wind power through advocacy, communication and education (awea.org, 12-01-2010). AWEA, founded in 1974, is a trade organization with around 2500 members representing wind power project developers, equipment suppliers, services providers, parts manufacturers, utilities, researchers. AWEA is well established with frequently quoted and referred to industry reports, fact sheets and statistic database and hosts several events every year such as workshops, conferences and fairs, the largest one being the annual spring AWEA WindPower conference which last year hosted over 20000 attendees in Chicago. (awea.org,13-01-2010) The conference provides presentations on the latest industry trends, technology developments, policy developments and valuable industry networking opportunities.

AWEA’s staff is currently working closely with Congress to ensure that the interests of the wind industry are addressed in the new energy legislation. Detwailer (23-11-2009), Manager of State Legislation and Policy at AWEA, describes the legislative work by AWEA as creating consensus and educating Congress by meeting with all of the 100 senators. The success of such a process is through understanding the concerns of the industry as well as the current political issues in order to figure out what to lobby for. Currently there is a lot of focus on job creation in the US and therefore Detweiler (23-11-2009) explains that it at the moment is important to find success stories of factories been built thus creating jobs within the wind energy industry.

Further AWEA has collaborations with regional partners in order to promote the growth of the wind industry at the local, state and regional level, the partners are presented in the table below. These regional partners largely focus on key transmission issues as well as state legislative and regulatory activities. AWEA is then also a member of each of these organizations to promote national and regional coordination (awea.org, 14-01-2010). The Wind Coalition, which is primarily active in Texas, is a strong wind promoter which will be further discussed in chapter 6.1.

Table 9 Overview of Regional Industry Organizations *(awea.org, 14-01-2010)*

Partners	Region

Alliance for Clean Energy New York	New York
Interwest Energy Alliance	Arizona, Colorado, Nevada, New Mexico, Utah and Wyoming
RENEW New England	Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut
The Wind Coalition	Texas, New Mexico, Kansas, Oklahoma, Arkansas, Missouri, and Louisiana
Center for Energy Efficiency and Renewable Technologies	California
Mid Atlantic Renewable Energy Coalition	Pennsylvania, New Jersey, Delaware, Maryland, West Virginia, Virginia, North Carolina, and the District of Columbia
Renewable Northwest Project	Washington, Oregon, Montana

4.3.1 Movements against Wind Energy

Besides these pro wind organizations there is also a strong opposition towards wind. Two such groups are The Industrial Wind Action Organization and the National Wind Watch. These are groups claiming to inform the "real facts" about wind energy "beyond the sales pitch" and provides arguments that the effectiveness of wind in terms of reducing emissions is limited as is its impact on environment, economy and quality of life (windaction.org, 12-01-2010; wind-watch.org, 12-01-2010).

Further the social acceptance of wind in the US seems in general to be quite good, however the prevalence of NIMBY's (Not In My Backyard) is threatening. According to developers the number of NIMBY's is very much dependent of the region. Surprisingly this is the case in the North Eastern states where the NIMBY's often are pro green energy but they do not want to hear or see the turbines themselves. Further the impact of this movement is especially large in these areas since they are allowed to express their dissatisfaction and hinder project development through appeals.

4.4 Academia & Research

Although wind research in the US is lagging behind Europe some strong initiatives have been undertaken the last years as an action to meet the growing competence need. Nowadays there are a few clusters of universities and trade schools in the US that together with the national laboratories constitutes the bulk of research being conducted in the US. This chapter will briefly touch upon the prominent universities and laboratories and also include their collaborations.

4.4.1 Universities

The two major clusters of Universities devoted to wind research in the US are situated in regions where there are significantly large amount installed wind or a high presence of manufacturers.

The first cluster is in Colorado where there are a number of schools involved in control and electrical engineering dependent on the fact that there are several manufacturers present in that region. Two of these schools are University of California Boulder and Colorado School of Mines whom both work closely with the National Renewable Energy Laboratory located in Boulder, CL. (Lackner, 12-11-2009)

The other cluster of schools focusing on wind research and programs identified are located in the Texas region, the region in the US with the largest amount of installed capacity. These schools include; the University of Texas Austin, Texas Tech, the University of Houston and Texas State Technical College. Between some of the schools formal collaborations have been formed as a consequence of initiatives founded by the Wind Coalition to establish a center of excellence and expertise in Texas. (Lackner, 12-11-2009; McGowan, 12-11-2009)

The eldest university involved with wind energy research is the University of Massachusetts Amherst that since the 1970's has researched the area. The university got a chance during the early 1970's, through a National Science Foundation solicitation, to develop wind power for use when heating buildings. They built a 25kWh computer controlled wind turbine and had about a dozen student enrolled in this program. During the 1980's, when the federal government shifted focus to development of large scale turbines, UMASS-Amherst continued some experiments within aerodynamics as well as was assigned to develop a program on wind-diesel hybrid systems by NREL, a market that never really took off. However they managed to remain good at siting issues and resource estimations and thus today their main area of research is within instrumentation and looking over radar to get reliable and quick data. (McGowan, 12-11-2009)

4.4.2 The National Laboratories

Although the university realm is currently mobilizing its strengths to support the growing industry the expertise in the US is still very much centered to the national laboratories, like the National Renewable Energy Laboratory(NREL) in Boulder, CO, and Sandia in Albuquerque, NM. Both of these national laboratories are so called "GOCO", Governmentally Owned Contractor Operated organization, which implies that the facilities and equipment are owned by the government but the operations and maintenance is run by a contractor (Thresher, 16-12-2009). NREL's current contractor is "the Alliance for Sustainability" and the contractor for Sandia is Lockheed Martin. Sandia which has been a national laboratory since 1949 has a focus on science-based technologies that support the national security, ensuring and enhancing energy (sandia.gov, 14-01-2010). The NREL, founded in 1979 under the name Department of Energy's Solar Energy Research Institute (eurekalert.org, 12-01-2010), on the other hand is strictly focused on the renewable energy.

The NREL does basic research and is currently one of the few research centers carrying out experiments on actual turbines. NREL has both a Siemens 2.3 MW, where aerodynamic experiments are done, and a GE 1.5MW. In 1999 they started the Wind Partnership for Advanced Component Technolgy (the WindPact) in order to better assist the industry in lowering the cost of energy by designing and testing innovative components (Thresher, 16-12-2009). However these collaborations with industry, independent of whether it is from a university or the NREL, have become increasingly harder to perform due to intellectual property rights issues. The industry is becoming more secretive and from the university side they are not asking for advice but rather looking for graduates. (Thresher, 16-12-2009; Lackner, 12-11-2009; McGowan, 12-11-2009)

4.4.3 Collaborations in Academia

In the US Universities need to send in their proposals or respond to a solicitation in order to receive funding from federal or state government. In the case of UMASS, the university submitted nearly 2000 proposals for external funding in 2009 totaling in $338 million, corresponding to a 36% increase from the year before. The high number of proposals as well as dollar amount was due to the federal opportunities that opened up with ARRA. (umass.edu, 15-01-2010) This application process promotes competition which sometimes involves teaming up with others hence promoting university-university collaborations (Lackner, 12-11-2009). During 2009 the Department of Energy put out a $24 million dollar solicitation for three industry-research consortium within wind development. These were very sought after and UMASS teamed up with MIT, Penn State and Siemens in order to qualify. This specific solicitation from the DOE was aimed at facilitating the otherwise difficult industry-university collaboration.

Another example of an ongoing collaboration between universities is the Texas Wind Energy Institute, a team-up between Texas Tech University and the Texas State Technical College (TSTC) promoted by the Texas Wind Coalition. The purpose of this collaboration is to educate students to meet the workforce needs of the wind industry in Texas. TSTC has the experience of training wind technicians since 2007 provides safety, apprentice and technician certifications and Texas Tech which has had a Wind Science and Engineering Research Center (WISE) for over 30 years, have since 2003 been developing programs in wind energy research and offers a first of its kind PhD degree in wind science and engineering. Both of these schools are located in the tip of the wind corridor and TSTC in a region which has >60% of the wind energy in Texas. The certifications and the joint efforts have the purpose of strengthening the reputations of the schools in order to attract industry relations which would allow the schools to identify the right type of competence needs. (depts.ttu.edu, 12-01-2010)

How these collaborations will evolve is uncertain since some argue that the DOE solicitations accompanied to ARRA will let the industry actors play an increasingly important role in the future R&D. This might have a negative influence due to the seemingly lack of collaboration between industry and universities. Other stress that the independent role of NREL, who is only collaborating on a long term basis with a selected few universities, further weakens the collaborations within the industry.

5 Empiric Chapter – Part II

This part covers the issues related to IS's broader context which are derived from issues highlighted during interviews, industry conferences and literature. These include policies, electric infrastructure, project financing, technology development and price of wind powers and competition from incumbents.

5.1 US Energy Policies

This chapter is divided into three parts where the first will provide some basic understanding of the different federal political initiatives and institutions that have historically as well currently had impact over US energy policies, including the Department of Energy and the office of Energy Efficiency and Renewable Energy. The second part will describe the current administrations initiatives, focusing largely on the American Recovery and Reinvestment Act and briefly discussing the various energy legislations currently under discussion in Congress. The final part will provide more detailed information regarding the two most important policy tools for wind energy; the various types of tax benefits and the renewable portfolio standards.

5.1.1 Introduction to the federal US policy environment and its institutions

The US policy environment for renewable energy sources is less subsidized than the European markets. Germany, which has had a feed-in-tariff in place since 1990 and has secured a very large base of installed capacity (Jacobsson & Lauber, 2006) is by many considered the success story of renewable energy in Europe. However the electricity produced from wind energy comes at a higher price than in the US. Subsidizing in that sense has never been the "American way" and therefore a general opinion is that any variations of such a policy tool in the US is very unlikely (Karsner, 31-10-09). The US resistance towards these types of subsidies can sometimes go so far as saying that Germany is hindering the development towards a cost efficient technology and that there is a need for a stronger global competition. However this does not mean that there are no incentives given to renewable energy source or that there have not been historically.

The main driver for energy policy in the US since the 1970's has been the strive for energy independence; an issue that both republicans and democrats seem to agree upon is important. During the midst of the oil crisis in the early 1970's President Nixon launched the Project Independence with the goal for the US to become energy self-sufficient by the year 1980. (energy.gov, 06-01-2010) Although a lot of these efforts were put into nuclear overall there was an increase in R&D spending for all forms of energy at the time. Later in 1977 President Carter signed a "Department of Energy Organization Act" which called for an official Department of Energy (DOE) (energy.gov, 06-01-2010). The department was to be responsible for federal energy administration and R&D as well as at the time the nuclear weapons program. Contained into the structure of the department was a separate division for renewable energy, then called Solar Energy, which gave the renewable energy sector a role in the federal government for the first time (energy.gov, 06-01-2010).

During the 1980's and the early 1990's, during the leadership of President Reagan and President Bush little focus was put on renewable energy source and most efforts were focused on refining nuclear energy (energy.gov, 06-01-2010). However President Bush came to sign the Energy Policy Act of 1992 which included a production tax credit (PTC) for renewable energy producers for the first time. The PTC has later become one of the most important policy initiatives for the development of wind energy in the US. Once President Clinton was inaugurated in late 1992 a larger focus was put on reducing greenhouse gas emissions for the first time. (energy.gov, 06-01-2010) These kinds of "political cycles" have made it difficult for a sustainable long term support of renewable energy.

5.1.1.1 The Department of Energy & the Office of Energy Efficiency and Renewable Energy

The DOE's main mission today is to advance the national, economic and energy security of the US. (energy.gov, 07-01-2010) The department is involved in promoting science and technological innovation supporting their main mission and is "*the single largest Federal government supporter of basic research…*"(energy.gov , 08-01-2010).

The federal wind initiatives within the DOE are put under the office of Energy Efficiency and Renewable Energy (EERE). The main initiative being the Wind and Hydropower Technologies Program which has the ambition of improving the performance, lowering the cost and accelerating the deployment of wind and water power technologies (eere.energy,gov, 08-01-2010). Some of the ambitions of the wind program are the following;

1. ***Large Wind Technology***: By 2012, reduce the cost of electricity from large wind systems to 3.6 cents per kWh for land-based systems from a baseline of 5.5 cents/kWh in 2002.
2. ***Offshore Wind Technology***: By 2014, reduce the cost of electricity from large wind systems in class 6 winds (17.9 to 19.7 miles per hour) to 7 cents/kWh for shallow water offshore systems from a baseline of 9.5 cents/kWh in 2005.
3. ***Renewable Systems Interconnection***: By 2012, complete program activities addressing electric power market rules, interconnection impacts, operating strategies, and system planning needed for wind energy to compete without disadvantage to serve the nation's energy needs
4. ***Technology Acceptance***: By 2010, facilitate the installation of at least 100 MW of wind energy in 30 states from a baseline of 8 states in 2002; and by 2018, facilitate the installation of at least 1,000 MW in at least 15 states, from an estimated baseline of 3 states in 2008.

(eere.energy.gov, 09-01-2010)

Despite common belief President George W. Bush did put focus on greenhouse gas emissions, fuel efficiency and increasing the minimum of required levels of renewable fuels through the Energy Independence and Security Act (eere.energy, 10-01-2010). Karsner (31-10-2009), assistant secretary for the office of EERE between the years 2006 and 2008, highlights that in the final years of the Bush administration energy work became more important. Former secretary Karsner was personally involved with the much discussed and referred to study done by the DOE in 2008 examining the technical feasibility of using wind energy to generate 20% of the nation's electricity demand by 2030. The "20% wind energy by 2030" report concludes that it is a possible scenario if following measures are met (eere.energy.gov, 11-01-2010.

20 % wind by 2030 Initiative – measures required

Reaching 20% wind energy will require enhanced transmission infrastructure, streamlined siting and permitting regimes, improved reliability and operability of wind systems, and increased U.S. wind manufacturing capacity.

Achieving 20% wind energy will require the number of turbine installations to increase from approximately 2000 per year in 2006 to almost 7000 per year in 2017.

Addressing transmission challenges such as siting and cost allocation of new transmission lines to access the Nation's best wind resources will be required to achieve 20% wind energy.

Table 10 20% Wind by 2030 Initiatives (eere.energy.gov, 11-01-2010)

5.1.2 Tax incentives for wind development

The ***production tax credits*** (PTC) have historically been very important for the development of wind energy in the US. Since 1992, when the first PTC was enacted it has been extended for only one –two years at a time and has been allowed to fully expire at three occasions in 1999, 2001 and 2003 (awea.org, 10-01-2010) The cases when the PTC was not renewed or extended prior to its expiration date were followed by periods of significant decrease of new installations; these periods occurred in 2000, 2002 and 2004 as can be seen in figure 14. The market development's close correlation to the PTC's extension or lack thereof can according to Barbose et al, 2007, serve as limited evidence of the industry's strong dependence on the PTC.

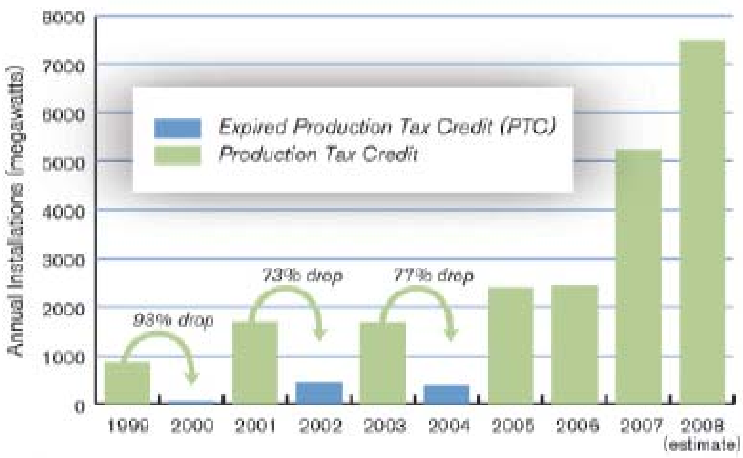


Figure 14 Overview of Historic Impact of PTC on Annual Installation of Wind Capacity (newwindagenda.org, 2010)

The industry's continuous adaption to the deadlines posed by the PTC has created an on-again, of-again pattern where it is either full speed when the PTC is in place or complete stop when it is not . The uncertainty that these boom bust cycles cause has, according industry actors, had a negative impact such as underinvestment in manufacturing facilities and installation of new capacity. Since other electricity generating technologies have their own forms of federal support, often written into a permanent tax law, AWEA argue that wind power is put in a disadvantageous position without a PTC. (newwindagenda.org, 08-01-2010)

5.1.2.1 The Current Types of Tax benefits Available for Wind Project

Production Tax Credit offers a $2.1 cent tax credit for each kWh of electricity generated by a qualified energy resource, the duration of the tax credit is 10 years. (dsireusa.org, 09-01-2010) The three year extension that was made under ARRA is thus so far the longest extension of the PTC and rund through December 31 2012, of this crucial policy tool (awea.org, 10-01-2010).

30% Investment Tax Credit a new incentive, included in the ARRA stimulus package gives a PTC eligible taxpayer the option to chose a 30% tax credit of the project cost instead of a credit on the production. (awea.org, 09-01-2010) Since most US developers lend the tax benefits over to large institutional investors in exchange for capital to build their projects the PTC became an inefficient tool last year as banks, investment banks and insurance companies ran out of tax base and therefore no longer needed the tax benefits. (Martin et al, 2009) For further read into project financing see Chapter 5.3.

The DOE together with the Treasury Department also provides the option for those receiving the ITC to get a cash grant directly instead of the investment tax credit so that developers could go ahead and get their projects started. The ITC will be available for projects placed into service between 2009-

2012. The cash grant option will be available for projects placed into service 2009 or 2010 and projects that are put into service before the credit deadline but where construction started during 2009 or 2010 (awea.org, 09-01-2010) however all applicants to cash grant program must be in by September 2011. (Martin et al, 2009) The Treasury Department is obliged to grant the application within 60 days and does then expect annual reports for five years on how the project is doing. (K Martin et al, 2009)

Another tax incentive of importance is the ***accelerated depreciation*** that means that a developer can write of 80% of the value in 5 years. Umanoff (18-12-2010) from the law firm Chadbourne Parks, estimates that the depreciation is worth 20-25% of the economic value of a typical wind project. The tax rules are advantageous since you do not need to use the depreciation today but can carry it forward for a long time. Furthermore the extended ***bonus depreciation*** issued under ARRA is a time limited offer allowing businesses to immediately write off 50% of the cost of depreciable property acquired in 2009 for use in the US, the other half will thereafter be depreciated as normal (awea.org, 09-01-2010). This extra depreciation is worth toughly 1,9 cent per dollar of capital cost and is offered by the US government to further spur new investment while the economy remains weak (Martin et al, 2009).

Manufacturing tax incentives is a new tax credit issued under the ARRA and provides a 30% credit for investment in a “qualified advanced energy manufacturing project.” (awea.org, 09-01-2010) The projects include establishment, expansion or re equipment of a manufacturing facility for the production of property designed to be used to produce energy from the wind among other categories. ARRA limited the total value of such credits allocated to $2.3 billion and the credits are only available for projects approved by the Treasury Secretary in consultation with the Energy Secretary. (awea.org, 09-01-2010) The applicant will have three years from the date of certification to put a project in place.

Since the new ITC and the cash grant was issued most developers have chosen this option however there seems to still be large difficulties in financing projects in the current economic climate. Although these tax incentives provide strong policy tool as of now there is still great uncertainty what will happen after 2012 when the current PTC and the ITC expire.

5.1.3 Renewable portfolio standards – State Initiatives Leading the Way

A Renewable Portfolio Standard (RPS) or a Renewable Electricity Standard (RES) as previously discussed is considered very important for the future development of renewable energy in the US. Although a cap-and-trade program in the long run would help to make renewable energy more cost competitive the carbon price in the near and medium term will remain too low to drive renewable energy on its own. (renewableenergyworld.com, 08-01-2010)

A RPS is a measure by which the utilities are obliged to obtain a certain minimal amount of electricity from renewable energy sources by a certain date or through purchasing tradable renewable energy credits (RECs) from electricity produced elsewhere. AWEA has put out their guideline that a federal RPS should call for a 25% of the US electricity to come from renewable energy sources by 2025. (newwindagenda.org, 08-01-2010)

RPSs have already been implemented in over 20 states and the effects of such legislation have been proven to be influential for the development of wind. The RPSs in California, Illinois, Minnesota, New Jersey, and Texas create the five largest markets for new renewable energy growth in the US (ucsusa.org, 09-01-2010). CERA (14-12-2009) estimates that with the current state RPS levels the US would see around 7% of US power coming from renewable energy by 2020 whereas with a strong federal RPS 20% would come from renewable sources by 2020.

The levels set by the different states vary a lot with on the one hand Texas setting easy to reach target, 2800MW in 2009, and on the other hand states like California pursuing very ambitious percentage targets (M. Sloan, 09-12-2009). The figure below shows the 28 states that currently have implemented a RPS and the levels of renewable energy they are pursuing. Six of these states, North Dakota, South Dakota, Utah, Virginia, West Virginia and Vermont, have established non binding goals for the adoption of renewable energy instead of a RPS, and the California RPS has elapsed and is therefore not in the figure.

Figure 15 State RPS's ***(dsireusa.org, 10-01-2010)***

So far it has been these state initiatives that have been one of the major drivers of wind development. In most states a REC market has been implemented to support the RPS. Looking at federal alternative a difficulty lies within implementing a REC market that trades between states. (CERA, 14-12-2009) Most of the regional REC markets are either limited to only include a specific state, like in the case of Texas, or very limited trade between states. However some of the North Eastern states, have according to CERA (14-12-2009), managed to make their REC markets more interconnected and liquid, at least in theory.

For states that already have a RPS in place a federal initiative will have less impact. It is therefore of interest when structuring a federal RPS to focus on the regions currently lacking state RPSs in order to understand how these would be able to reach the considered target. (EERE, 18-12-2009) Today the majority of the states without RPS’s are in the South West, a region largely lacking renewable energy resources, in order for a federal RPS to function properly a REC market which allows these states to purchase REC from other places must be put in place. The Emerging Energy Research firm (18-12-2009) concludes that a federal REC market quickly becomes very hard to structure so that it suits everyone especially with the underlying US transmission problem which will be further investigated in the next chapter.

5.1.4 Initiatives by the Obama administration

Since President Obama came into office in January 2009 important initiatives have been undertaken that have, will and might affect the future development of wind energy in the US. First and foremost the American Reinvestment and Recovery Act (ARRA) of 2009 have already had an apparent effect on the wind industry. The bill that was passed in February 2009 has provided several important policy initiatives that have enabled a continued growth of installed wind capacity despite the overall economic downturn (AWEA,2010)

Further the strong Obama-Biden New Energy for America plan, which was articulated during the election campaign, stirred up discussions of passing a comprehensive climate change and energy legislation which led to a number of bills initiated in Congress. The original Obama-Biden plan included reaching the target 10% of electricity from renewable energy sources by 2012 as a short term goal and 25% by 2050 as well as implementing an economy wide cap-and-trade program making the US the world leader when it comes to climate change issues. (change.gov, 08-01-2010)

5.1.5 American Recovery and Reinvestment Act

ARRA as a response to the financial crisis and was an effort to create new jobs, spur economic activity and invest in the long term economic growth. The act was targeted at building up infrastructure including investments into the domestic renewable energy industry and the weatherization of houses and federal buildings. (recovery.gov, 08-01-2010)

In total $787 billion dollars will be spent by the recovery act and out of these $ 36.7 billion went to the DOE, the division within the department is shown in the pie chart below. The majority of these funds went to developing renewable energy or adjacent technology research. The $16.8 billion in funding that went directly to the office of EERE meant a near tenfold increase in budget for the office in comparison to 2008. (eere.energy.gov, 13-01-2010)

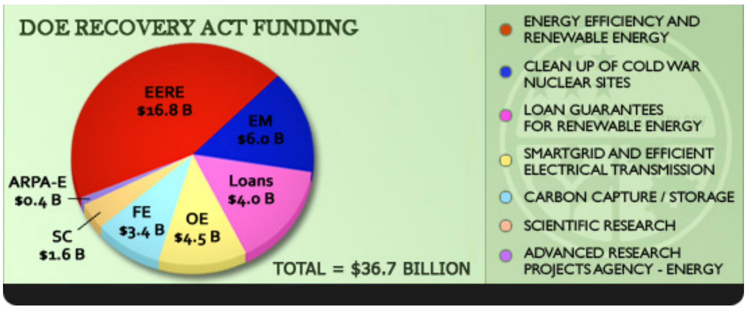


Figure 16ARRA funding DOE, *(.eere.energy.gov, 13-01-2010)*

Out of these funds $93 million dollars went directly to the development of wind energy in the US though solicitations (eere.energy.gov, 14-01-2010). The projects that were funded were created to increase the reliability of wind energy and create new job opportunities as well as expand the clean energy economy.(eere.energy.gov, 16-01-2010) Another $25 million was offset for a wind technology testing center in Massachusetts and another $100 million were announced in funding to NREL for facility and infrastructure improvements.(eere.energy.gov, 14-01-2010) The chart below shows the direct investment to wind technology from the ARRA as handed out by the EERE;

Table 11 ARRA funding for wind, *(www1.eere.energy.gov, 14-01-2010)*

EERE ARRA –Direct Appropriations to the Development of Wind Energy
$45 million to wind turbine drivetrain R&D and testing Enhancing the federal government's ability to support the wind industry through testing the performance of current as well as future drivetrain systems
$14 million for technology development Advance technology development in the private sector and aim to improve the quality and use of lighter weight, advanced materials for turbine blades, towers, and other components.
$24 million for wind power research and development Develop three consortia between universities and industry to focus on critical wind energy challenges. Will allow universities to develop R&D programs and work with the industry to improve power systems operations, maintenance and repaire and component manufacturing
$10 million for National Wind Technology Center This funding will enhance the National Renewable Energy Laboratory's ability to support the wind industry through testing facilities at the National Wind Technology Center in Colorado
$25 million for Wind Technolgy Testing Center Funding a large blade testing facility in the Boston Harbor. Once finished it will be the first the first commercial large blade test facility in the US, allowing for testing of blades longer than 50 meters, something that prior only could be done in Europe

5.1.5.1 Loan Guarantees

Besides these initiatives that have been appropriated directly to the wind energy industry another important part of the DOE 's ARRA initiatives have been the loan guarantees that have been issued for renewable energy. One of the larger projects, awarded a $16 million conditional loan guarantee, was Nordic Windpower USA for supporting expansion of an assembly plant in Pocatello, ID, in order to facilitate the production of is 1 MW wind turbine.(eere.energy.gov, 16-01-2010)

5.1.5.2 Renewal and Introduction of Tax Credits

However the seemingly most important policy affecting the wind industry issued under the ARRA was the decision to renew the production tax credits for another three years and issue a new 30% Investment Tax Credit (ITC) as an option instead of the PTC. Further $3 billion dollars were announced to be issued for renewable energy projects providing direct payments in lieu of the ITC for projects built from2009 up until the credits termination date, this to allow an immediate stimulus in local economies. This initiative was a joint effort between the DOE and the Department of Treasury and the ITC recipient can therefore be qualified a grant from the Department of Treasury instead of tax credit (eere.energy.gov, 18-01-2010). Further $2.3 billion was issued through a new 30% manufacturing tax credit. The recipients had to go through a competitive bidding process in order to receive the funding. (awea.org, 09-01-2010) The historic impact of tax credits for the wind industry has been very important and a more in depth explanation of the various options will follow later on in this chapter.

5.1.5.3 Extended Bonus Depreciation

ARRA also extended the bonus depreciation for capital expenditure incurred in 2009. Bonus depreciation permits wind project developers to immediately write off 50% of the cost of depreciable property acquired in 2009 (awea.org, 09-01-2010). Further ARRA also authorized issued new clean renewable energy bonds for $1.6 billion in order to finance facilities that generate electricity from the various renewable resources including wind (awea.org, 09-01-2010).

5.1.5.4 State Energy Program

$3.1 billion have gone to the State Energy Fund (SEP),a federal-state partnership implemented by the state energy offices (eere.energy.gov, 13-01-2010). These grants, designed to fund energy efficiency and renewable energy, are only allowed for states that intend to pursue policies to promote energy efficiency and renewable energy as in line with the recovery act. For a state to be qualified for the SEP fund the governor is required to write a letter to the Secretary of Energy to confirm the state's initiatives. (energy.gov, 18-01-2010)

In conclusion the ARRA have opened up a whole array of new opportunities for renewable energy developers, manufacturers and universities. The most important efforts for the wind industry that have been discussed in this chapter are shown in the table below, the propositions are divided by the ones of most interest for developers and manufacturers

Table 12 Most important ARRA incentives for the wind energy industry

Developers	Manufacturers
Extension of PTC	**Manufacturing Tax credit**
The option of an ITC	**Extension of bonus depreciation**
Treasury Grant Program	**Loan Guarantee Program**
State Energy Program	**Applied R&D funding**
Extension of bonus depreciation	
Applied R&D funding	
Loan Guarantee Program	

The Energy Information Administration, the independent statistical agency with the DOE, posted an updated energy economic outlook 2009 reflecting the impact that the provision of the ARRA would have on future wind development;

Table 13 Projected future effects of ARRA on wind energy generation

"The EIA expects that by 2012 wind generation is, as a result of ARRA, more than twice the amount that was projected in the no-stimulus case. Further by 2030 the total installed wind capacity is projected to be 67% greater than previously forecasted due to the ARRA-stimulus" (EIA, 2009)

5.1.6 New Initiatives for Climate & Energy Legislation

Soon after the installment of the new administration the first draft of a clean energy legislation was released. ***The Clean Energy and Security Act of 2009*** was put forward by Chairman H. Waxman (D) of the Energy and Commerce committee and Chairman E. Markey (D) of the Energy and Environment Subcommittee already in March 2009 and was passed through the House of Representatives in June of 2009, indicating a new found US commitment for climate issue and renewable energy.

However in the US regulatory system a bill has to pass both the House of Representative and the Senate before a final joined version is put in for the president's approval where after the bill becomes law. The fact that a senate version of the HoR bill has no yet passed has darkened the outlook of a substantial climate legislation implemented in the US anytime soon.

Since the HoR act was voted through several different Senate initiatives have been discussed, two of them which has been voted through their respective committees. All the current bills as of Jan 2010 and what they include are summarized in the table below.

Table 14 Overview of the different federal energy initiatives *(thomas.gov, opencongress.org, Kerry.senate.gov, energycommerce.house.gov, climaterprogress.org)*

Act/Framework	*Renewable Portfolio Standard*	*Cap and Trade*	*Latest Action*
House of Representative initiatives			
***The Clean Energy and Security Act of 2009* - Markey/Waxman Bill**	20% from renewable electricity by the year 2020 , short term target would be 6% by 2012.	Cut Emission by: 83% of 2005 levels by 2050	Passed through the HoR, 29-01-2009
Senate Initiatives			
***The American Clean Energy Leadership Act* - Bingamann**	15% in 2015, with the short term goal of 3% in 2011-2013. Includes a federal Renewable Energy Credit trading program	Does not include specifications on a cap and trade	Approved by the Senate Energy and Natural Resources Committee, 16-07-2010
***Clean Energy Jobs and American Power Act* - Boxer/Kerry Bill**	Does not include an RPS	Reduce GHG emission 20% below 2005 levels by 2020 and 83% by 2050	Placed on senate legislative calendar 02-02-2010
***Carbon Limits and Energy for Americas Renewal* - Cantwill/ Collins Bill**	Does not include an RPS	Reduce U.S. emissions by: 20% relative to 2005 levels by 2020 and 83% by 2050.	Introduced in the Finance Committee 12 -12-2009
Kerry-Lieberman-Graham framework	Does not include an RPS	Pollution reduction target: around 17% below 2005 levels and approximately 80% below in the long term	Framework sent into the President 10-12-2009

The current situation, with a democratic majority in both the Senate and the House is very rare and leads to less bipartisan proposals. However when Congress be reelected in 2010, all of the house of representative seats are up for election together with a 1/3 of the Senate seats, the political situation might change implying that bipartisan approaches will become increasingly important (Karsner, 31-10-2010). The Kerry-Lierberman-Graham framework has acknowledged this potential development and is a collaboration between a democratic, an independent and a republican senator. The framework tries to comprise the interests along party line and thus has a stronger emphasis on domestically produced oil and natural gas together with nuclear and clean coal solutions in order to ensure US energy security together with strengthening renewable energy sources.

The latest bill proposed in the Senate is the ***Carbon Limits and Energy for Americas Renewal.*** in this bill the allowances to emit would not be distributed free as is the case of the Markey-Waxman bills instead the allowances would be auctioned out and the proceedings would go to the individual consumer as a method of keeping the price down. Although the bill has been acknowledge for its simple and straightforward methods the Senate Majority leader, H. Reid(D) has already backed the Kerry-Lieberman-Graham initiative and it is discussed that the CLEAR act will have a hard time braking through since it most likely will not be backed by industry (climateprogress.org, 09-01-2010).

In conclusion CERA (14-12-2009), identifies the most important drivers going forward for wind as a Cap and Trade scheme and a federal RES, estimates that a carbon regulation could pass in 2011 however a federal RES is a bit more politically volatile. A federal RES which is more targeted towards renewable energy is considered to be a stronger driver than a Cap and Trade scheme in the short term and therefore is the policy approach strongly promoted by AWEA (newwindagenda.org, 08-01-2010). It is thus yet difficult to point exactly to the effects that the proposed legislative initiatives will have on the future development of the wind energy.

Concluding this chapter on Renewable Energy Policies and future important policy instruments is a statement from Detweiler (23-11-2009), Manager of state legislative and policy at AWEA, "the main thing that the US wind market needs is a federal RPS, transmission will come as a consequence…."

5.2 Overview of US Electric Infrastructure

This chapter will describe issues that are related to the US electrical infrastructure, first a general and a historical overview is presented, followed by a presentation of the major challenges and current ongoing initiatives.

5.2.1 Transmission infrastructure in the US is insufficient

The lack of sufficient transmission in the US is a problem since most sources of renewable energy tend be located far from the load centers, i.e. where electricity is consumed, this is especially true for wind. When comparing the location of the windiest regions and the regions with most transmission, see figure 17 and 18, little correlation is seen. Not being able to transfer the generated electricity to load centers makes those regions unattractive to wind developers despite their great wind resources.

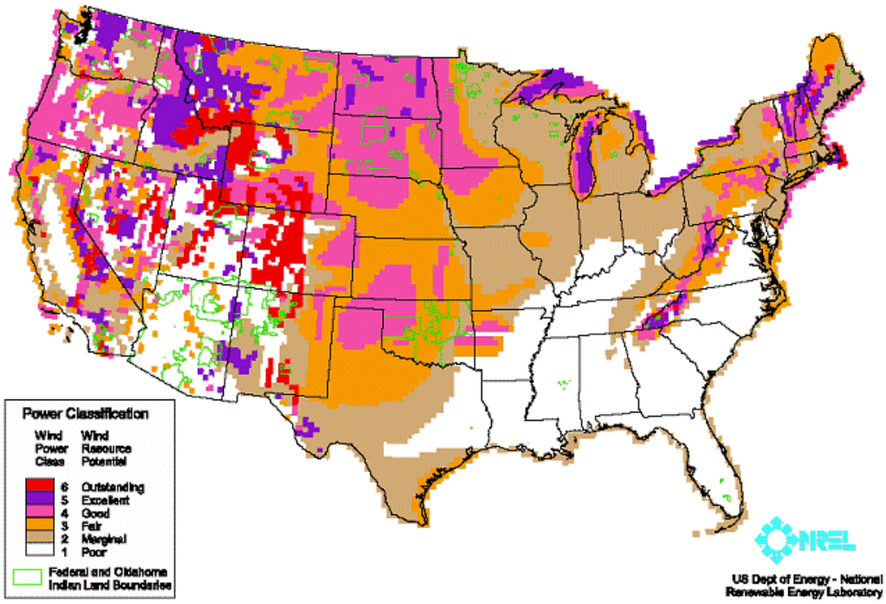


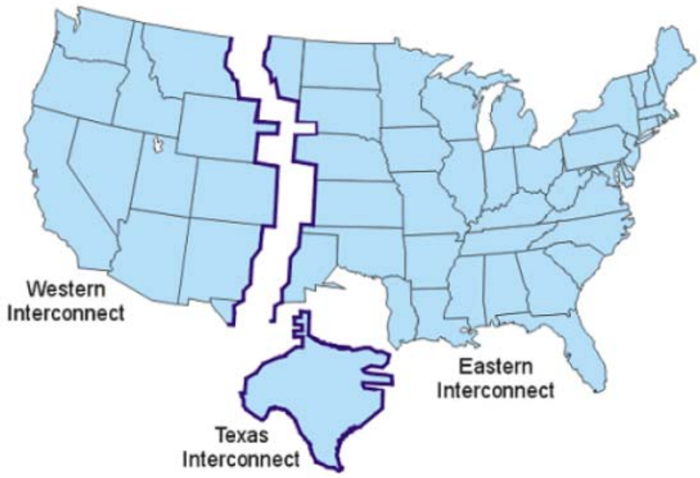
Figure 17 Map of US Wind resources *(Heinrich Böll, 2009)*

Figure 18 Map over US transmission infrastructure *(Heinrich Böll, 2009)*

It varies between regions how much transmission is still available but as most good wind sights with access to transmission have already been explored the lack of transmission is viewed upon, by all types of industry actors, as one of the greatest challenges facing the US wind energy industry. According to a publication by AWEA and Solar Energy Associations (SEIA) (2009) almost 300,000 MW of wind projects, are waiting in line to be interconnected to the grid across the US. The issue is well recognized and the report "20 Percent Wind Energy by 2030" by Department of Energy (DOE, 2008) identifies the lack of transmission as the largest obstacle of future growth of wind installations.

5.2.2 Historic overview of the US energy infrastructure

Understanding what is needed to move forward in the development of an efficient US electrical system requires insights on basic facts regarding the regulatory environment, its structure and the history of the current system.



Source: US Department of Energy

Figure 19 Overview of the US three interconnect regions *(Heinrich Böll, 2009)*

As shown in figure 19 the US electricity infrastructure is complex but mainly consists of three large regions; the Easter, the Western and the Texas Interconnect. The interconnect regions in turn consist of seven Regional Transmission Organizations (RTOs) and Independent System Operator (ISOs) that coordinate all generation and transmission, operate wholesale electricity market and provide non-discriminatory transmission access, see figure 23 (Heinrich Böll, 2009). Of the RTO's and ISO's ERCOT, SPP and MISO are the most important for wind development (CERA, 14-12-2009).

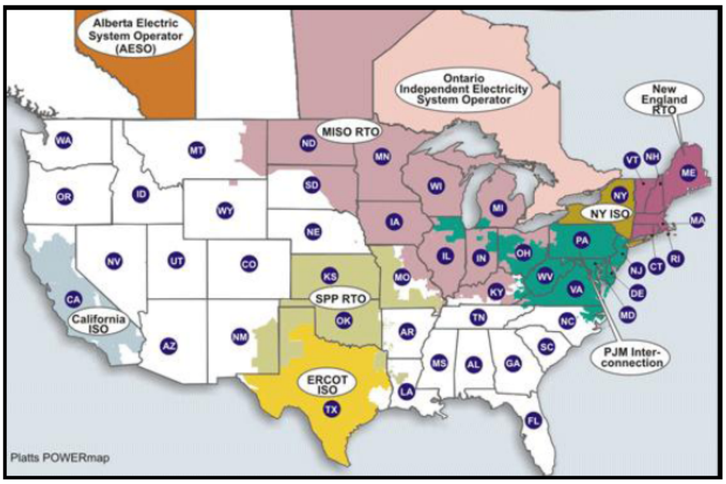


Figure 20 Overview of the RTOs and ISOs in the US *(Heinrich Böll, 2009)*

Historically prior to the deregulation, that took place in 1980s and 1990s, utility companies were not required to purchase or transmit power from third parties and their business models were therefore focused on vertical integration (Heinrich Böll, 2009). Small utilities and cooperatives were interconnected to the larger utilities' grids and together they formed regional systems of power, these systems rarely had meaningful interconnection between each other (Heinrich Böll, 2009).

The lack of sufficient interconnection led to a severe blackout in 1965 in the northeastern part of US which in turn led to more focus on interconnection and eventually a deregulation of the market. During this period of time the government established regional reliability councils which later in the

1990's became the RTOs and the ITOs. (Heinrich Böll, 2009) After the deregulation the non utility power generators became much more important and common in the US energy mix however a nationwide interstate electricity market, similar to the European one, has yet not been developed due to the lack of transmission and interconnection between states however the most developed markets are in the northeastern RTOs (CERA, 14-12-2009).

Furthermore due to the low price of energy, utility companies have traditionally developed their infrastructures according to a lowest cost approach and the systems have therefore been poorly upgraded (Harding, 21-10-2009). Incentives for building transmission have been lacking since it historically has been cheaper to ship the fuel for generating electricity close to the load stations rather than shipping electricity (Heinrich Böll, 2009). This has led to few transmission lines designed to solely to transmit large quantities of electricity and transmission expansion has thus grown significantly slower than energy production (Heinrich Böll, 2009).

5.2.3 Major challenges related to transmission

Despite the complex transmission system the main issue is, according to AWEA and SEIA, policy barriers (2009). Traces from the historical regional approach of electricity generation in the US are also seen in the regulatory environment. It is very complex with multiple overlapping jurisdictional responsibilities among federal and state commissions and agencies, and a lack of one single regulatory force. As a general rule the Federal Energy Regulatory Commission (FERC) controls the wholesale power sales and interstate transmission tariffs, it is then the state commissions who control permitting and siting issues as well as the retail rates within the states. (Heinrich Böll, 2009) This forces transmission projects spanning over several states to seek regulatory permission at the commission of each state, a very cumbersome approval process that can ad years of delay which is why transmission projects have been reported to take up to a decade to develop (EERE, 2009; CERA, 14-12-2009)

Industry actors and networks are asking for political leadership, a federal transmission plan and a holistic perspective on the issue where one single regulatory force is in charge. They claim the country need a new model for siting and permitting procedures for transmission lines across state boarders to make the procedure less complex and transparent, many propose that FERC should be that regulatory force and get jurisdiction over both siting and rate regulation as it does for natural gas pipelines.

Another issue hindering the development is the cost allocation of the lines. Utilities are generally reluctant to commit to build transmission without a guarantee that the lines will be utilized and the developers and investors are reluctant to commit to a plant without a guarantee that sufficient transmission exists and it does become an "chicken and the egg" problem (Heinrich Böll, 2009). A viable solution to this problem may be the Texan Competitive Renewable Energy Zones (CREZ) model which is a proactive transmission planning approach where all stakeholders are involved in picking suitable zones and actually building the transmission (read more in Chapter 6.1). Currently other states than Texas, e.g. California and Colorado but the outcome of the Texan CREZ projects is, according to actors involved with transmission issues, expected to have an impact on how the build out of transmission will happen in the rest of the country.

5.2.4 Ongoing government initiatives

From the American Recovery and Reinvestment Act (ARRA) $3.25 billion each have been allocated as borrowing authorities for the Power Marketing Administrations; Bonneville Power Administration serving the Pacific Northwest; and the Western Area Power Administration in serving the south western states. These administrations are independent entities within the DOE that market wholesale electricity and transmission (energy.gov, 25-01-2010). Furthermore $4.5 billion have been allocated to the Office of Electricity Delivery and Energy Reliability (OE) part of DOE, these funds will be spent on a nationwide plan to modernize the electric grid and will be mainly focused on Smart Grid development, but the money will also be used for conducting a resource assessment and analysis on future transmission requirements (oe.energy.gov, 25-01-2010).

5.2.4.1 IPPs building their own transmission

The scarcity of transmission has made new actors join the field and developed their own electricity infrastructure. One example is the US largest wind farm owner NextEra, an IPP but also a subsidiary to the large utility company FPL Energy, who built their own transmission line in Texas reaching over 700 kilometers in order to ensure that their energy will be sold. For the coming decades, or until the government catches up, this trend is likely to last and a hand full of strategic and financial investors are expected to invest heavy in transmission because they realize they have a first mover's advantage (Umanoff, 18-12-2009). Wind project developers are also likely to be able to do more of smaller electricity grid build outs to interconnect their wind projects but lines of over 700 kilometers like NextEra's might still be uncommon (Umanoff, 18-12-2009).

5.3 Project financing

This chapter will introduce the issue of financing of US wind projects. It will discuss the role of PPAs and the policy's affect on project financing.

Access to project financing is a strong driver for the industry, to a high degree this depends on the industry's dependence on the tax credits. Because of the vast tax benefits that come with the PTC and the accelerated depreciation most developers cannot absorb that large amount of tax benefits. It is therefore common to take in an equity investor with a large balance sheet, such as an industry conglomerate or an investment bank, who can monetize the benefits; these types of investor are called Tax Equity Investors. The equity financing of the project is then often divided between the project developer who gets the cash flow from the generated electricity and the tax equity investor who benefits from the tax credits and the depreciation. (Umanoff, 18-12-2009)

The PTCs have made the industry very reliant on tax equity investors and when the economic downturn hit the tax equity market during the fall of 2008 project financing became very hard to come by as the tax equity market almost came to a complete stop (CERA, 14-12-2009). By 2007, prior to the recession, there were around 20-25 major institutions in this space and it was a competitive business with larger supply of tax equity than demand. During the fall of 2009 the investors started to come back, both for equity and debt, but what saved the continued growth were the ITC and the new cash grants in lieu of the ITC that came in place with the ARRA (CERA, 14-12-2009; Umanoff, 18-12-2009). The grants have allowed new developers to grow stronger since they no longer need to have a large US tax base to be able to monetize the tax benefits, this has benefited foreign actors a lot and Ibedrola from Spain is so far the largest recipient of the grant. However a large US tax base is still needed to be able to monetize the value of the accelerated depreciation (Umanoff, 18-12-2009).

5.3.1 Power Purchase Agreements

The electricity generated by wind farms is either sold on the market or sold to a utility company via a long term contracts with a predetermined price called Power Purchase Agreements (PPA) (EERE, 2009). According to many industry experts to come by project financing you will need to have a PPA in place, however due to the current low electricity price it is debated whether PPAs are difficult to sign today or not. The difference between regions is big, but factors that are supposedly making it difficult to sign a PPA are that utilities due to the current low demand for electricity are less desperate to sign new agreements, difference of opinion makes negotiating long term contracts on what is a fair price difficult, and finally that an increasing amount of utilities wants to build their own wind farms rather than buying PPAs (EER, 18-12- 2009; CERA, 14-12-2009).

On the other hand some say that they have not seen a decline in the pace that PPAs are being signed but they are often contingent. One major obstacle for successful project is finding transmission, and utilities recognize that developers cannot always take the transmission risks, therefore signed into the PPA is the developer's right to walk away from the contract at no cost if transmission does not arrive on time and for a reasonable price (Umanoff, 18-12-2009).

Owners of wind projects have increasingly over time chosen to taken on some merchant risk as they allow a portion of their electricity sales revenue be tied to prices determined by the spot market rather than being locked in through a long-term PPA. In 2008 43% of the wind power capacity added did not enter a PPA, the equivalent number for the cumulative capacity in 2009 was 23%, a majority of these latter projects are located in Texas, New York, and several mid-Atlantic and Midwestern states where a wholesale markets exists, where wind power has been able to compete with the spot prices, and where additional revenue may be generated from the sale of Renewable Energy Credits (RECs). However as wholesale power prices plummeted in late 2008 and through the first half of 2009 merchant activity is expected to diminish in the immediate future. (EERE, 2009)

5.3.2 Policy's affect on project financing and other trends within project development

The policy incentives and the tax system have a profound impact on how project financing is carried out for wind projects and thus it also has an effect on ownership. A part from making project developers reliant on tax equity investors and its market, its rules have other impacts, e.g. tax credits are only eligible on "passive" income, which in the US means that there is no opportunity for private investors investing in wind projects and funds are included (Umanoff, 18-12-2009).

It is uncertain what will happen when the stimulus program runs out which will happen in 2011 for the grants and in 2012 for the ITC (awea.org, 09-01-2010). To overcome shortages in access to project financing the large turbine manufactures are expected to increasingly offer vendor financing, since it is another tool they can offer to their customers and it is also a way to increase revenues (Umanoff, 18-12-2009). Today GE is doing so, and Siemens is also talking about it during the AWEA, 2009 Wind Energy Fall Symposium.

The utilities with large balance sheets and a large US tax base can continue to benefit from the PTC when the ITC and the grants are no longer in place but it may hamper the foreign investors (Umanoff, 18-12-2009). In 2008 15% of new installations were accounted for by utility companies, the number has been approximately the same for the previous three years (AWEA, 2009). Despite this fact many in the industry are talking about an increasing interest from large utility companies to join the field, for example the large utility in Iowa MidAmerica have said that they would rather operate their own wind farm than signing a PPA since they believe it will be cheaper for them (EER, 18-12-2009). In the beginning the utilities fought the state Renewable Portfolio Standards but several of them are now more positive, and those that support them have often made an agreement that they will be allowed to own and operate wind farms which many IPPs are against since it could lead to an unfair competition (Umanoff, 18-12-2009).

Concluding this chapter is an example of project financing structure provided by Umanoff (18-12-2009)

An example of a project financing structure

Size of project: 200 MW project
Cost of project: Capital cost $400m
$2m/MW of which $16 000/ MW for the turbine, balance of plant and transmission upgrades
Preconditions: No ITC or grants in place

1. A commercial bank loans $400m on a short term base (1year – 18 months) for constructing the project (construction loan = 100% of construction costs)
2. At completion of construction the construction loan converts to a term loan that will run for 10-15years, the length of the loan is dependent on the term of your off-take contract to sell your power, the PPA. With a 20 years PPA contract you can get 15 years financing, if only 10 year PPA lenders will only give you 8 years.

   The lender will not make the long term loan unless you have committed equity investors. Equity typically is 40-50% of the total capital, in our example with the when the project is completed the structure might be $175m of equity and the $225 m of a 10 or 15 years term loan.

3. The equity piece typically have two types of investors
   a. The developer who are investing because they want to enjoy the economic returns from selling the energy
   b. The Tax equity investor who enjoys the tax benefits from the PTC and the accelerated depreciation, e.g. Morgan Stanley or JP Morgan Chase

   The legal structure is very complex and it allows the tax equity investor to jointly own the project with the developer and the tax equity investor to absorb all the tax credits and the developer all the cash flow.

Table 15 Example of project financing structure, *(Umanoff, 18-12-2009)*

5.4 Technology Development

In order to further grasp the technology and its relative competitiveness towards other sources it is not only of importance to understand the competition but also to understand how the internal technology and its reliability will evolve. This chapter will start with a general discussion of the turbine technology trends and will then later be broken down towards focusing on two current and important topics, techniques for siting and techniques for maintenance in the US.

Wind energy is today the most reliable renewable energy source available and the technology development has therefore already come a long way. There is no basic research being conducted today and the development contains of incremental innovations. Thresher (16-12-2009) from NREL wants to compare the industry with the automotive industry when it comes to technical development, thus suggesting that the whole evolution of wind has been compiled of small enhances with a revolutionary breakthrough coming along once in a while. For a long period of time the focus of the industry was put on the constructing larger turbines, a US component supplier grouped the turbine evolution into three generations where the first was 20-50kW turbines, the second 500-600 kW and the third 1 MW. When discussing a possible fourth generation anytime soon he argued that the defect rates are still too high for the 2.5-3 MW machines that are currently being developed. Lackner (12-11-2009) from UMASS agreed that in terms of size the turbines will continue to stay around 1-2 MW but that the reason for this lies mainly in road and transportation issues.

Further the issues of faltering components is still of great concern for the industry (Goodwill, 18-12-2009). Gearboxes e.g. tend to break 10 times more often than they should and focus is very much directed towards developing better technologies for gearboxes. The US is trying through federal initiatives to solve this issue with a NREL study dedicated to gearbox reliability and a DOE solicitation for a gearbox testing facility (Lackner, 12-11-2009). BTM (2009) conclude that gearboxes are in need for continuous improvement and the long time frame from design development to delivery of the first series of a new gearbox is 2-3 years makes this area of research very important to the industry. Vestas try to solve these issues by working closely with the suppliers mitigating the cost of technology with shorter lead times in the US through setting up a repair facility for gearboxes in CO (Goodwill, 18-12-2009). Currently drive train technology, a substitute to gearboxes, are being researched and developed however they're often too heavy to be a cost efficient alternative in large scale turbines (BTM, 2009a).

Blades are also of concern since they are a big fraction of the cost and also very closely related to performance. BTM (2009a) adds that as the turbines grow bigger a primary driver for blade design is stiffness and lower weight. Sandia National Laboratory currently has an innovative blade research center where they study segmented blades, blade divided into two sections that would make the transportation of larger turbines easier. Enercon has already made a 6 MW turbine with segmented blades however the manufacturer is not currently represented on the US market (BTM, 2009; AWEA Fall Symposium, 18-11-2009)

As previously mentioned US wind industry is extra cost conscious and in the current economic downturn this focus has become even more apparent. The component suppliers concluded that the industry is now more than ever focused on the cost of energy which puts a high pressure on performance issues. An article in Windpower Engineering reinforces this issue by listing the main consideration for how the industry can further reduce the cost of producing electricity (Norz, 2009). These considerations, largely focused on the reliability of wind turbines, have also received a lot of attentions at industry conferences during the fall and seem to be the focus of the industry at the moment and are listed below;

1. Swept surface or rotor diameter
2. Better site selection
3. Reducing the cost of capital and the maintenance costs

The first consideration includes, Swept Surface or Rotor Diameter, involves the more general technology development such as building larger turbines that can leverage economies of scale. This involves developing new blade designs and rotor speed ratios in order to extract the maximum power of the wind. This field is highly research with the industry although kept secret in to gain competitive advantages. The next two considerations will be discussed in further detail separately.

5.4.1 Siting Issues

It is obviously best to place wind turbines in areas of strong sustainable winds, however selecting sites requires extensive study of the areas topology and annual wind speeds. Site suitability is therefore a critical component when developing a wind farm and at the AWEA Fall Symposium 2009 seminar was devoted to the issues relating to siting. Bleeg from Garrad Hassan (19-11-2009) focused his attention to the important influence of wind loads. He argued that the assessment of wind loads is important due to the following;

1. The loads to which a turbine is subjected have a direct impact on the life of the turbine
2. If the turbine is not suitable for the site conditions, it will likely lead to large repair and downtime costs
3. Warranty is contingent on the manufacturer accepting the turbine design which has to correspond to the wind loads

Modern utility scale wind turbines are designed according to certain standards; International Electrotechnical Commission (IEC) and Germanischer Lloyd (GL), and therefore correspond to a specific set of wind conditions for a generic site type. The design certification verifies that the turbine has been designed according to prevailing standards to achieve a 20-year life when operated under conditions corresponding to the specific wind class. (Bleeg, 19-11-2009)

Table 16 Classification of wind turbines according to specific wind conditions. (Bleeg, 19-11-2009)

IEC 61400-1, Edition 2 (1999)	Class I	Class II	Class III
Extreme wind speed, 50-year return, 10-minute average (m/s)	50	42.5	37.5
Annual mean wind speed (m/s)	10	8.5	7.5
Turbulence Class A Characteristic Turbulence Intensity at 15 m/s	18%	18%	18%
Turbulence Class B Characteristic Turbulence Intensity at 15 m/s	16%	16%	16%

Some argue that these standards are not sufficient for the US since the wind resource in certain areas of the country are much stronger than in Europe and that the turbines therefore are too weak to run at a capacity factor of up to 40%, which is the case at some of the best sites in US. If the characteristics are not in line with the standard parameter this might lead to an accelerated default rate. Putting turbines up on mesas and mountains gives great wind condition but also provides compression of winds that lead to funnel effects and even more extreme wind speeds.

Computational Fluid Dynamic (CFD) codes are currently advancing, with research being conducted both in Europe and in the US, and soon it will become easier to simulate specific wind behavior such as swirls and wake zones in order to better place the turbines in terms of power production (Dvorak, 2009, Lackner, 12-11-2009). According to some suppliers the industry is currently just starting to discover the true mechanics of wind turbines in the sense that it has not previously been able to measure wind speeds precisely in front of the rotor and across the rotor. At a mesa due to compression, the highest wind can be at the bottom and not at the top of the rotor due to compression. In the Midwest e.g., where turbines reach high altitudes (5-600 feet), there are problem with jet-streams, and there is a need for geographically specialized turbines along with the improvements of siting assessment in order to get the most out of the turbines and to avoid high failure rates (Möller, 24-11-2009).

5.4.2 Reducing the cost of capital and maintenance

The overall project costs and the complex machinery of the turbine have according to the Norz (2009) in Windpower Engineering many areas where costs can be trimmed. The article discusses the advantage of a two blade solution instead of the more common three bladed turbines. However there are plenty of different areas which could be of interest to this aspect, one of the largest concerns being maintenance.

At the AWEA Fall symposium the panelist Poore (19-11-2009), from DNV Global Energy Concepts, went through the warranty trends in the US. The warranty structures have changed during the 2000's, starting with extensive long term coverage with high availability guarantees (97%) to less beneficial terms during the years of shortage of supply. Today, as a consequence of the economic down turn, the picture has changed again and is now more advantageous for the customer. As demand returns it will become increasingly important for customers to be aware of warranty risks and what they can do to hedge against them (Poore, 19-11-2009). The warranty risks he warned for were; leaving the warranty period with latent defects resulting in higher than planned future costs or lower availability and leaving the warranty period without sufficient knowledge to manage project since the maintenance has mainly been handled by the OEM's.

The panel following Poore (19-11-2009) agreed upon that in order to avoid extensive failures the use of condition monitoring is key, such systems help to optimize and enable the turbine owner to better understand their turbines. If the US continues to underestimate the importance of maintenance services and equipment, by not optimizing the maintenance policies, the overall life time cost will increase and in some cases large expensive retrofit projects will be necessary. (AWEA Panel, 19-11-2009)

Another consequence of neglecting the area of maintenance and the use of condition monitoring is that there will be a lack of field data available for improving turbine designs. Today in the US more than 80% of the installed turbines are younger than five years, and these turbines are primary designed for European conditions. Due to the strength of the US wind resources, turbines installed in good wind resource areas produce over 50% more electricity than the same turbines in Europe, this as previously described causes higher failure rates. As the installed base grows the challenge of keeping track of such performance and durability trends becomes bigger (AWEA panel, 19-11-2009). Further with the expected growth the grid managers become increasingly reliant on power expected to be produced by wind power. Therefore the prediction of wind power supplied to the grid becomes crucial and project and turbine reliability becomes valuable indicators of the ability of a wind project to meet electricity supply expectations (AWEA panel, 19-11-2009).

5.4.3 The role of the DOE

Concluding this discussion of trends in technology development the role of the DOE is described. Through stimulus money the DOE have gotten much stronger influence on the direction of research and through ARRA the DOE arranged committees with experts from the industry and academia in order to construct the necessary solicitations. Although this process of choosing research focus of the solicitations may seem thin McGowan (12-11-2009) argues that it is better than no initiative at all and that the larger attention will most likely promote the topic of wind energy studies further within Universities. Lackner (12-11-2009), also from UMASS, added that the task the DOE was put in charge of was a difficult challenge; the department received large fundings, little time together with a political pressure of spreading the funding across the nation. Lackner (12-11-2009) argued that in terms of the breadth of initiatives the DOE have done a pretty good job in funding applied research, workforce development, program for small business, community development etc. However he would have liked to have seen more stimulus funding appropriated to basic research. The DOE has gotten more influence on the technology development both within the industry and academia and Thresher (16-12-2009) from NREL concluded that there is a tendency in the US for the DOE to pick winner and losers in the technology realm.

Concluding this chapter on technology development a DOE Wind Technologies Market Report 2008 project costs seem to be on the rise mainly due to the increasing cost of turbines and further, some argue even more alarming, the performance improvements appear to have leveled out the most recent year.

5.5 Price of wind power and competition from incumbent energy sources

This chapter will describe the role of wind power in the US energy mix, further it will investigate what are the most threatening energy sources in terms of competition and finally discuss what drives the prices of wind and what that development looks like.

Wind currently provides around 1.4% or more of the total energy production in the US and that level is expected to increase (BTM, 2009b). Since 2005 wind projects have accounted for a significant part of new installed power generation capacity, seen in figure 21, in 2008 completed wind projects equaled to around 42% of new additions, this number was 35% in 2007 (AWEA, 2009). According to EIA (2009) Natural Gas and Renewable Energy, mainly wind, are expected to account for the majority of new power generation until the year 2035 and perhaps longer.

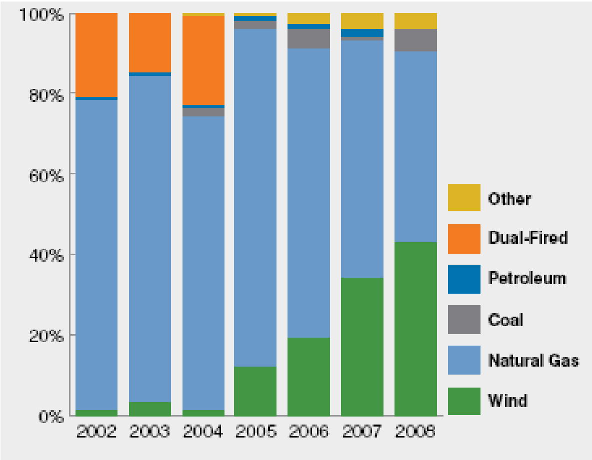


Figure 21 Overview of the US energy mix, new annual new installations *(AWEA, 2009)*

The main competitor for wind power is natural-gas-fired plants which are cheaper to build than renewable or nuclear plants. Adding to the competition an increased production of shale-gas in the US through use of new technologies has lowered the price of natural gas in the country as well as increased the estimated remaining resource base of natural gas which drives the price down (CERA, 14-12-2009). Electricity prices in the US are closely linked to natural gas prices and following its recent decline; natural gas is expected to play an increasingly important role in the US energy mix (eia.doe.gov, 25-01-2010). Additionally interviews with industry actors have shown an expected increase in push back from incumbent energy suppliers in the form of stepped up lobbying efforts.

Wind power has been able to remain competitive in wholesale power markets during the last five years. Though it is difficult to take into account all the cost of wind projects or the complete cost of incumbent energy sources, especially concerning emissions, on an average wind projects installed since 2003 have been priced lower or at the lower end of the average wholesale price range. The prices of wind vary much by region; Texas, Heartland and Mountain regions have the lowest prices and East and New England have the highest prices (EERE, 18-12-2009).

Though wind has managed to be competitive the cost of wind projects has increased 2002-2003, seen in figure 22 below. Rising wholesale prices has mitigated the increased costs however as energy prices have decreased due to the recent economic recession and the increase of natural gas supply the wind industry will experience stronger competition (EERE, 2009).

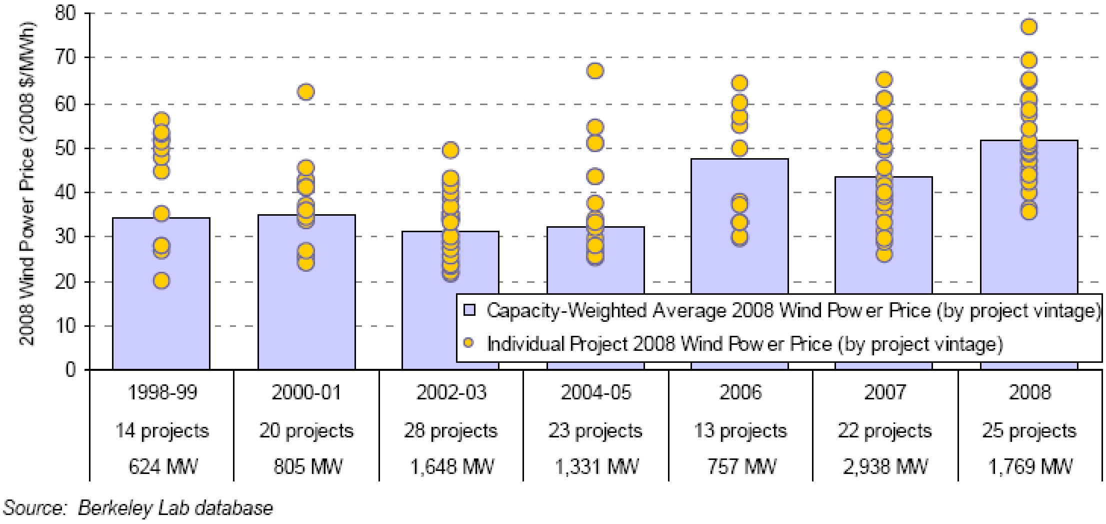


Figure 22 2008 Wind Power Prices by Project Age *(EERE, 209)*

Two of the most important drivers of wind power sales prices are installed project costs and project performance (EERE, 2009). Historically wind project installation cost has decreased significantly; from the 1980’s to 2000’s they have fallen by roughly $2700 kW, however during the recent years it has yet again increased. Higher price on wind turbines, caused by lower value of the dollar, increased turbine size and cost of material and shortage in supply, are some of the main factors behind this recent trend. (EERE, 2009) Prior to 2009 it was a seller’s market however during the recent economic downturn supply has improved and the customer have gained stronger bargaining power which has somewhat strengthened the bargaining power of the customers again.

Wind project performance has improved significantly over the years the improvement comes from higher capacity factors due to technical advancement of turbines and of site assessment tools. The weighted average of the capacity factor increased from 22% prior to 1998 to 37% in 2007 however, in 2008 this number was down again to 35% (EERE, 2009). Reasons for the decline lie within curtailment of projects in Texas, project developers prioritizing transmission access before wind quality of the sites and increased failures of gearboxes and blades (EERE, 2009). Cost of maintenance has historically decreased, partly due to increased size of wind farms, however the speed of that decline has slowed down. As wind farms grow older the cost of maintenance is likely to increase due to retrofits and defaulting components (EERE, 2009).

6 Empiric Part III

This empiric part provides two separate case studies. The first is a case study of Texas where the topics discussed in the two previous empiric parts are applied. The second case study describes a potential entry strategy through investigating Swedish Biogas International, a Swedish clean-tech company that successfully established a subsidiary in the US.

6.1 The wind energy industry in Texas

This chapter has the purpose to give a more in depth understanding of the various topics described in Part I and II by giving an example of the industry development in Texas. First a brief background of the Texas wind industry is presented, after that a few policy topics are discussed. Secondly the state of the supply chain and the electricity infrastructure is presented and finally industry networks and collaborations are described.

6.1.1 Texas state- Background and Introduction

Texas is the second largest state in terms of both population and size it is also both a large producer and a large consumer of energy. Despite abundant resources of wind and solar the fraction of renewable energy has historically been among the lowest in the country instead production of energy has mainly been based on oil and natural gas

In 1992 Texas became a net importer of energy,largely based on the declining oil and gas production coinciding with an increasing population and demand this did not suit the Texan independent identity and culture. The situation created momentum for the renewable energy community who together with a few utilities and state leaders advocated for renewable energy which eventually led to the implementation of a RPS and increased acceptance of wind power (Sloan, 09-12-2009). Today Texas is by far the state with the most installed capacity of wind power with a base of 9410 MW it is also home to some of the world's largest wind farms (awea.org, 19-01-2010).

Due to Texas strong conservative tradition there is a strong emphasis on promoting competition and the state's electricity market is one of the most deregulated in the country. To support competition and promote installation of new power generation there is an open access approach in Texas which works well in combination with a competitive wholesale generation market with no interconnection queues and socialized transmission(Sloan, 09-12-2009). With exceptional wind resources, the ability to build low cost large scale projects, the support from an effective RPS and the increase in natural gas prices , has enabled wind to compete with incumbent energy sources and reached costs under 3 cents/kWh (with federal tax incentives) (Sloan, 09-12-2009).

6.1.2 Expected Market Development

In 2009 Texas once again outperformed the other states of the country as 2292 MW were installed. This corresponded to almost 25% to the total installed capacity during 2009. Today the installed capacity of wind power in Texas is exceeding the target of 10 000 MW from renewable energy sources by 2025 (awea.org, 19-01-2010). The strong growth taking place in 2007-2008 was according to Sloan (09-12-2009) mainly driven by the high price of energy, mainly natural gas. However with the recent economic recession and the low energy prices that came as a consequence have made wind power in Texas more challenging and in short term less profitable. New transmission is currently being developed in the state and some investors with a long-term perspective continue to invest in new wind projects however generally Sloan (09-12-2009) adds that these are difficult times for making new investments and instead he sees potential for an investor to purchase distressed existing assets at an attractive price.. With the previous success of wind power development in Texas Texan industry actors though warn for an increasing threat from the incumbents who still have a lot to say when it comes to state policy and the legislative environment.

6.1.3 The successful implementation of the Texas RPS

The RPS put in place 1999 was considered a strong driver for the wind development in the state, Sloan describes it this way in *"The Texas RPS serves as an impressive example of what effective energy* *policies can deliver: from concept to $1 billion worth of results in less than three years."* (Sloan, 09-12-2009) The key elements of the Texas RPS according to Sloan (09-12-2009) are presented here.

First the legislative process of implementing the RPS was efficient, further it was supported by a state law enacted in 1995 called Integrated Resource Planning (IRP). The IRP required utilities to seek input from their consumers on resource planning. As it turned out a majority of people across Texas were willing to pay a premium for more clean energy which made the utilities more supportive of the RPS discussions.

Secondly the specified mandate was not set too high but considered achievable, first they were set to 2000 MW by 2009. This goal was met already in 2005 which made the Texas legislature increase the state's RPS to 5,880 MW by 2015 and set a goal of 10,000 MW in 2025. (seco.cpa.state.tx.us, 20-01-2010) Further clear roles and responsibilities were assigned as well as meaningful penalties and functional rules and regulations. Each retail electric provider, were required to obtain the amount of renewable energy corresponding to their market share and penalties of up to $50/MWh for non-compliance were introduced.

Thirdly, to meet the RPS targets a market for Renewable Energy Credits (RECs) was established where one REC represents one MWh of qualified renewable energy (seco.cpa.state.tx.us, 20-01-2010). The RECs were initially put in place to validate compliance by electric companies with the RPS but soon RECs were adopted for use by anyone wanting to make voluntary environmental claims regarding the use of “green power”. The voluntary market grew with 250% between 2002 and 2003 and further spurred the growth of renewable energy in Texas.

6.1.4 The influence of landowners in Texas

The landowners are important stakeholders in wind projects. In exchange for leasing their land out they receive royalties often consisting of a fixed annual payment according to the size of the land, and a variable amount based on the amount of electricity produced. In Texas the landowners are either ranchers, with huge land areas; or farmers with smaller pieces of land. Since it is considered easier to develop wind farms with fewer landowners involved wind development in Texas was expected to be a ranch thing only. However the largest wind energy project in the world, the Roscoe project in West Texas, paved way for a change since it was built on farmland and comprised more than 100 land owners. This further opened up for more potential great wind sites on farm land (Wortham, 11-12-2009). An important success factor in this shift was local actors who represented the landowners (see example below). It is increasingly common for project developers to locate such a person often called a “land agent” (or local project initiator) since they speak the language of the local people and can help developers to navigate in the local regions (Wortham, 11-12-2009).

The development of large projects in Texas is further supported by a regulatory friendly environment and little bureaucracy which according to Sloan (09-12-2009) depends on the state’s “preference for no-nonsense, pro business rules” and its “acceptance of large energy production projects”.

The Specific Example of Cliff Etheredge and the Roscoe Wind Farm ***(Based on interview with Cliff Etheredge, 10-12-2009)***

Cliff Etheredge, a cotton farmer in Roscoe TX, became such a 'land agent' in 2000 when he started to explore the possibility to develop wind power projects in his region. He started talking to the other cotton farmers in the region about wind as a new source of income, he arranged meetings and seminars where wind actors where invited to speak. After a couple of those gatherings he could see the opinions change among the forty landowners involved.

The next was to set up a met-tower on his farm to gather wind data, after many setbacks he managed to get very good results and went to present his data at wind conferences. After a while he managed to attract a wind developer to come and explore the site. As the project started to take off Cliff mobilized an additional 80 landowners and the developer put up seven met towers to validate his previous results.

The region does not only have access to wind resources but also oil. During the era of intensive oil production in 1940-50's transmission lines were built from West Texas down to the Austin and Dallas areas to utilize the natural gas for electricity production on the site. These transmission lines together with good met-tower results and a unified group of landowners made Roscoe a very preferable site for wind farm development. Soon Airtricity bought the project and today it has been acquired once more by E.ON Climate & Renewables.

Today the Sweetwater region, including Roscoe, has more than 1600 wind turbines installed and a generation capacity of around 3 000 MW. The area is also home to Texas State Technical College, a state agency and state technical college that provides education for wind technicians, and several new primary and secondary schools that have been funded by money coming from the wind

Table 17 The case of the Roscoe wind farm

6.1.5 The state of the supply chain in Texas

So far none of the large turbine manufacturers have located manufacturing facilities in Texas instead neighboring states such as Kansas and Colorado have seen more of that. However the turbine manufacturers have other types of offices in the state; Vestas has a R&D facility in Houston TX and a warehouse in Dallas TX, GE has a customer service center in Sweetwater TX, Siemens has a customer service center in Houston TX and Gamesa has a development office in Dallas TX and Austin TX.

Wortham (11-12-2009), at the Texas Wind Energy Clearinghouse, says that a reason to why the state misses out on foreign investments by large turbine manufacturers may be the lack of a formal commitment by the Texas government, e.g. upgrading the RPS. In addition, Wortham says, other states have governors who are actively trying to attract these companies through personal action and state commitments e.g. Pennsylvania managed to attract Gamesa by making specific promises to the company.

According to a report by DOE (2009) there are twelve manufacturing facilities in Texas supplying to the wind industry, five for towers, one for blades, one for turbines and the rest for other components. In the Sweetwater TX region Wortham (11-12-2009) appreciates that around forty companies have been established related to the wind industry, mainly connected to service. When it comes to jobs related to clean energy in general in Texas as a whole is ranking second to California and in 2009 had around 4 800 businesses in the field and over 55 000 jobs tied to the sector. (windcoalition.org, 25-01-2010)

6.1.6 The Electricity infrastructure of Texas

In line with the state's independent culture and legacy Texas is the only state with its own electricity grid. The grid, Electric Reliability Council of Texas (ERCOT), has very limited interconnection to other grids and the initial connections were done for grid reliability reasons. Culturally and process wise ERCOT differs from the other grids. To support competition and promote installation of new power generation during the period of low reserve margins in the 90's chairman Pat Wood of the Public Utility Commission took an important decision and implemented a "frontier free approach" to interconnection. This enabled any type of power generation to connect to the grid and allocated the cost of new transmission to all the end costumers instead of having the project developer paying it.

In other parts of the country wind projects are stuck in long interconnection queues due to the lack of transmission. In ERCOT the project developers are allowed to connect to the grid although with the contingency that if potential wind generation is greater than the capability of existing delivery infrastructure the project might get curtailed meaning that the wind farm will be forced to stop generating electricity. Furthermore, all the regulatory entities that govern ERCOT are located in Austin TX which enables efficient policy development that allows transmission projects to be built more quickly than transmission projects in the rest of the country. These are key distinctions between the Texas electricity market and other regional markets in the rest of the country. (Sloan, 09-12-2009)

To avoid vested interests for specific sources of energy the deregulation of the electricity market separated the different entities on the electricity market into three entities; firstly the competitive market for power generators, secondly the regulated utilities (regulated by the PUC) who owns the wires, and thirdly the competitive retail sales market. This essentially makes the people who own the power plants different from the people who sell the power. The power selling entities therefore do not care who produces the electricity and just want power with certain conditions such as low price, this market structure has enhanced competition. (Sloan, 09-12-2009)

6.1.6.1 Competitive Renewable Energy Zones

To support a continued build out of renewable energy sources in Texas the proactive transmission building regime, called Competitive Renewable Energy Zones (CREZs), was implemented as a part of the legislation passed in 2005 that also extended the state's RPS (lcra.org, 25-01-2010).

The law required the Public Utility Commission to consult with ERCOT and all concerned stakeholders to identify the zones in the state best suitable for developing renewable energy projects. Further they had to formulate a plan to construct transmission capacity necessary to transfer the electricity produced in such zones to end customers in the most cost-effective way (seco.cpa.state.tx.us 25-01-2010). To finance the transmission build out if a zone was chosen PUC either granted the transmission service provider with a Certificate of Convenience and Necessity (CNN) or ordered a utility to construct or expand transmission facilities, the cost of the construction and expansion could then be included in the utility's rate base. (windcoalition.org, 25-01-2010)

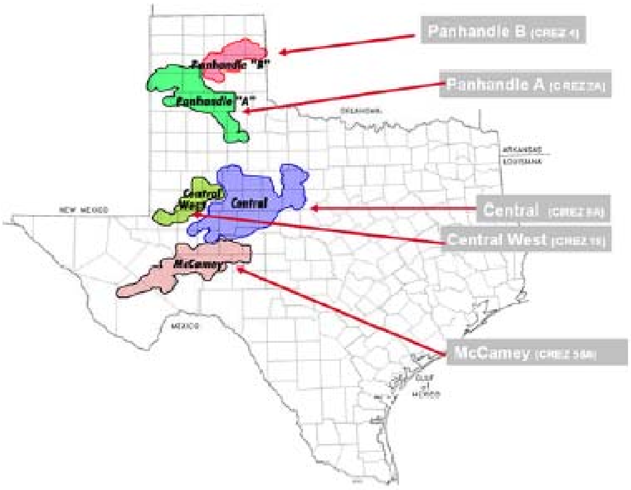


Figure 23 Map of Texas CREZ areas, ***(www.lcra.org, 20-01-2010)***

There were originally twenty-five CREZs nominations identified by ERCOT, each capable of generating 4,000 MW of renewable energy. Wind developers were then invited to give their top preferences for CREZ areas and to provide evidence of financial commitment to develop these areas. Finally five zones were chosen, see figure 23, which together will have transmission capacity to accommodate a total of 18500 MW of wind energy of which 6000 MW is already in operation (windcoalition.org, 25-01-2010).

According to industry consultants the project has gotten much attention and the outcome of the CREZ projects may serve as an important example and a milestone for the future development in US.

6.1.7 Industry Networks and Academia

There are several formal networks and industry organizations involved with wind development in Texas. The largest one, and the regional partner of AWEA in Texas, is The Wind Coalition, a nonprofit association with the mission to promote the development of wind energy at the regulatory and legislative levels within the ERCOT and the Southwest Power Pool (SPP) grid systems. The organizations members consist of actors in the whole supply chain from component suppliers, to turbine manufacturers, project developers and service providers. (windcoalition.org, 2010.01.25)

The Texas Wind Energy Clearinghouse is another industry organization including a broader range of stakeholders such as; school districts and counties, economic development institutions, colleges & universities, landowners and wind energy companies. This network has the purpose to create an arena for information exchange among its members on topics such as landowner issues, workforce recruitments, community economic development and more. (texaswindclearinghouse.us, 2010.01.25) Other networks that do the same are the Rural Alliance for Renewable Energy (RARE) (infinitepower.org, 25-01-2010) and the Texas Renewable Energy Industries Association (TREIA) (treia.org, 25-01-2010). Further networks such as that described in the Roscoe example (see Table 17) also play an important role in the state.

Involved in these networks are also representatives from academia, an example is the Texas Wind Energy Institute, a collaboration between Texas Tech University and the Texas State Technical College (TSTC), promoted by the Texas Wind Coalition (see chapter 4.4.) Further the West Texas A&M University has an institute called the Alternative Energy Institute (AEI) which primary focuses on wind energy and has a program focusing on wind data collection, turbine evaluation, and research and consulting (windenergy.org, 25-01-2010).

According to interviews with actors involved with the Texan wind industry these networks serve several important purposes such as promoting legislative actions, facing the increasing resistance from incumbent energy producers, educate landowners, create public acceptance and recognize local economic development.

6.2 Case study – Swedish Biogas

In order to better understand how a Swedish firm can successfully establish itself in the US market the case of Swedish Biogas International (SBI), which successfully established a subsidiary in Flint Michigan, has been studied. The case study includes a brief introduction to the Swedish company, how the company managed to successfully establish business in the US and the forces that made it work. Concluding are the crucial success factors that Swedish clean tech companies shall keep in mind when contemplating setting up business in the US. The information for this case study is based on interviews with Swedish Biogas International LLC's CEO, T. Guise and Swedish Consul General in Detroit, L Johansson.

6.2.1 Background of Swedish Biogas International

The story of Swedish Biogas International began in the late 1980s in Linköping Sweden where collaboration was set up between Linköping Municipality, Tekniska Verken i Linköping AB and the Federation of Swedish Farmers with the purpose to develop production of biogas in the city. The city's first biogas plant was completed in 1995 and today all of the city's buses run on biogas as well as many other commercial vehicles and a large number of private cars run on the fuel. (swedishbiogas.eu, 19-02-2010)

To be able to export the process knowledge developed in Linköping onto a national and international market Swedish Biogas International was formed in 2006. It is a private company with exclusive rights through license agreements to the know-how, the personnel and the practical experience within biogas and bio-methane developed at Tekniska Verken in Linköping AB and Svensk Biogas AB in Linköping. Today the company's core business is to design, optimize, operate and own biogas and bio-methane plants for environmentally friendly energy production from sewage sludge, organic waste and biogas crops. (swedishbiogas.eu, 19-02-2010)

The company has two international subsidies, one in Korea, *Swedish Biogas International Korea Ltd – Korea*, and one in the US, *Swedish Biogas International LLC – USA*. From 15 years of experience from operating and developing full-scale biogas and bio-methane production the technology can be considered to be fully proven. Furthermore the company can benefit from having access to full-scale production plants in Sweden that serve as important business references when exporting their technology. In addition the company has a laboratory and pilot plant where new or customized process solutions can be tested and access to the Biogas Center of Excellence in Linköping. (swedishbiogas.eu, 19-02-2010)

6.2.2 The move to the US

In 2008 Swedish Biogas won the Michigan Center of Energy Excellence award which started the move to the US. However the forces behind this award were many and complex, one of the strongest being the commitment of L. Johansson, Consul General in Detroit since 1997.

In 2007 L. Johansson invited the Swedish Minister of Enterprise and Energy Maud Olofsson, to meet with the leadership of Ford and GM. During this trip the minister also meet with governor Granholm, who has had a strong commitment toward turning the state of Michigan's manufacturing downturn to a leading green state implementing a state RPS in 2008 (Smith, 18-11-2008). The two of them put together a collaboration and asked Lennart Johansson to implement a plan that would promote Michigan as the first sustainable society in the US. The governor as a consequence decided to go to Sweden and several delegations from Michigan went over in advance to prepare her visit and performed due diligence procedures on specified industries and companies.

The due diligence team was headed by Doug Parks, Michigan Economic Development Corporation (MEDC) together with experts from the State of Michigan and several universities from Michigan. Lennart Johansson planned and organized the visit of the due diligence team and governor's visit. The governor arrived in August 2007 and attended SACC's E-days in Växjo, and visited Gothenburg where Business Region Gothenburg hosted an event with the participation of the leadership from VINNOVA, STEM, Gothenburg Energy and Chalmers. Ambassador Wood hosted a reception at his residence and the governor met most of the CEO's from Swedish clean-tech companies. The Swedish Triple Helix Model and the Michigan Center of Energy Excellence law

6.2.2.1 The Swedish Triple Helix Model and the Michigan Center of Energy Excellence law

During this trip the governor was encouraged to learn about the Swedish Triple Helix Model and she became interested in the Swedish way of working between government, industry and academia. The model had been proven to work in Sweden but was apparently new for the US and for Michigan i.e. in Sweden it is much more common for industry to fund academic research, through offering industry PhD's etc. However in the US the national laboratories and universities are much less integrated into the business arena, with some exceptions such as Stanford and MIT, and do not have the culture of collaborating neither among themselves nor between academia and industry. Prior initiatives had failed and consul Johansson mentions as an example that most universities in Michigan, when receiving funding from the state to commercialize new ideas have been unsuccessful

Governor Granholm together with Doug Parks, and Counsul Johansson put together a strategic plan to introduce various forms of clean energy in the state of Michigan. One tool was to implement a new state law, "The Center of Energy Excellence Law" which was enacted in 2008. The law was based on the Triple Helix model and included that state funding would be given to the industry with some claims that the funding must go to the creation of new jobs in Michigan and the industry would engage universities to enhance the technology, find solutions to problems etc. Under this law the state of Michigan can fund up to 50% of the project costs. Once resolved the industry would get the rights to commercialize the technology. The underlying thought of this development was that researchers would be able to stay in the academic sphere but still be able to make money from licenses.

Under this new law a number of projects were funded including the Swedish Biogas case. The investment started the development of a bio-methane center of energy excellence and involved the city of Flint, Kettering University and the MEDC (all parties involved are shown in the figure below).

Figure 24 Actors involved in bio-methane center in Flint, MI, (T Guise, 04-11-2009)

6.2.2.2 Swedish Biogas International – Flint MI

In 2007 Swedish Biogas International received the advantage of being recognized on the former US ambassador to Sweden, Woods, list of Swedish Clean Tech firms. The idea of the Ambassador’s list was to identify the best Swedish entrepreneurs in order to introduce them to U.S. clean-tech investors, since Sweden is according to Wood’s “*filled with entrepreneurs who have great ideas for alternative energy but who lack the capital to turn the ideas into a successful business*”. (Woods, 2008)

The advantage of being introduced to the US through the Woods list gave instant recognition as an industry leader and further led to the creation of the project in Michigan. Swedish Biogas International was awarded $4 million in funding from the state of Michigan and the MEDC to create biogas from the city of Flint's sewage plant (Phase I) and to generate biomethane (Phase II) for vehicles i.e. power city buses. The Flint Subsidiary further received $3million in funding from the Swedish Government to start up business in the US. The joint national efforts were later recognized by King Carl XVI Gustav when he together with Ambassador Wood, Ambassador Jonas Hafstrom, Consul Johansson and Governor Granholm broke ground to the project in September 2008 (US Embassy Stockholm, 16-01-2009).

Consul Johansson explained this as a “win-win” partnership between the US and Sweden; US gets new technology and Sweden gains export possibilities, in the beginning by mainly supplying most of the parts to the business but later on supplying the key components as well as the possibility of continuing other partnerships. The parent company keeps its technology secure since it simply licenses out the technology to the wholly owned subsidiary so that it can be exploited and receive funding in the US.

The US subsidiary which is located at Kettering University in Flint Michigan hired a US CEO, Thomas Guise, who together with the parent company and Linköping University is working on figuring out a specified technical solution that is appropriate for the US market.

In conclusion the subsidiary in Flint is a collaboration between Kettering University, MEDC, the city of Flint and the Swedish government and is thus the triple helix model personified as illustrated below.

Figure 25 The Triple Helix Applied to Flint MI and SBI *(Guise, 04-11-2009)*

6.2.3 Key Success Factors when establishing in the US – derived from the Swedish Biogas Case

First of all, having access to an already proven technology and full-scale projects serving as business references like Swedish Biogas International is very valuable since the US clean-tech market, according to Harding (21-10-2009), is, similar to other clean-tech markets, driven by business opportunities and cost of technology. A speaker at the Boston Clean-Tech Venture Day (BCVD) (10-11-2009) agrees with this and adds that when entering the US new issues will arise and therefore by having a finished product the company avoids any technical risks. In addition, by being able to display the concept in a full-scale project like SBI can do the business opportunity becomes more apparent which will make it easier to raise capital (BCVD-panel discussion, 10-11-2009).

A second important key factor is the possibility to adapt the technology and the business model to local preferences such as price, distribution or technical parameters. The legitimacy of Swedish clean-tech is strong in the US, it is considered durable, reliable, well engineered and producible and there are therefore great opportunities for Swedish clean-tech companies, however many overlook the need for local adaption (Harding, 21-10-2009). What Swedish Biogas has done is to aim at producing biogas with the same quality as natural gas and therefore being able to sell the gas on the market and utilize the extensive infrastructure for natural gas in the US (Guise, 04-11-2009).

Thirdly there are many obstacles for Swedish companies to enter the US, the Swedish companies are often quite small and lack the time and money to expand abroad. Additionally they are sometimes also scared of getting ripped off by investors or being sued by competitors in the US (Harding, 21-10-2009). Tom Guise, CEO of the US subsidiary of SBI and an American citizen, therefore believes it is important to have someone local or someone with experience from the US in his position like Swedish Biogas does (04-11-2009). However the support from a strong management team in the home country is very important, a speaker at the BCVD described the possibility of success of a clean-tech venture in the US as equaling the sum of the passion and the quality of the management team, the investors and the technology (BCVD-panel discussion, 10-11-2009). To be able to get the commercial benefits in the US and to raise capital it is important to have local presence either through a partnership with a US firm or by establishing a US subsidy like in the case of Swedish Biogas who received $4 million in funding from the State of Michigan and MEDC.

Finally, perhaps one of the most important things is to appreciate the importance of, and getting familiar with, the local networks in the US. SACC poses as a valuable example of a network that can help find partners and support and all other ancillary services a company needs such as lawyers and accountants etc. but also find customers and suppliers (Harding, 21-10-2009). In the case of the collaboration between Sweden and Michigan SACC played an important role when arranging the e-days in Växjö where governor Granholm got inspired to start the Center of Energy Excellence (COEE) in Michigan. With the award that SBI won in 2008 for the creation of a COEE they instantly got access to the State of Michigan's network.

Both Harding and Faulkner, (21-10-2009; 08-10-2009) consultants in Washington DC, underscore the importance of considering the state government and evaluating the political benefits or risk it might bring when deciding in what state to locate in the US. A panelist at the BCVD agrees and advices companies to carefully look at the individual states before entering the US since some states might fulfill more of a company's specific needs. In the case of Swedish Biogas, the Michigan government, Kettering University and the collaboration between these entities through a Center of Energy Excellence pose an example of how a specific needs were fulfilled, especially since SBI had been working in this type of constellation at home where it collaborates with the municipality and the Biogas Center of Excellence in Linköping. In the case of SBI identifying key players such as Johansson can give companies such as SBI a great introduction to the local market and networks.

7 Analysis

The analysis will start with assessing the current phase of the Innovation System followed by a functional analysis according to the Bergek et al (2008) theory. The functions are later summarized according to their historic influence on each phase of the IS's development. This discussion leads to the identification of Inducement and Blocking mechanisms of the industry moving forward. Derived from these mechanisms are potential business opportunities for Swedish component and service suppliers. The chapter is then concluded with a discussion of how to enter the US wind energy industry.

7.1 The Phase of the Innovation System

According to a general Industry Life Cycle (ILC) approach (Utterback, 1994; Klepper, 1997, Grant, 2008) an industry passes through three stages, first there is an introductory phase, a growth phase and later a phase of maturity. The Innovation System literature further divides the development of an IS into a formative phase that leads into a nursing market where a learning space is incorporated for the technology to develop, then suddenly the technology development changes gear and moves into a phase of growth.

When applied to the analyzed IS it is currently in a period of strong growth with the basic product design stabilized. However since the technology was developed and demand was initially created in Europe there seems to have been no natural formative or introductory period for the technology in the US. The lack of a nursing market/learning space has left its mark on the industry through a scarce knowledge base and a need to adopt the technology to the local conditions.

Further, the ratio quality/cost is increasingly becoming the basis of competition on the US market which is a characteristic, according to Utterback (1994), of the "specific phase" when an industry is reaching maturity. This implies, according to theory, that small changes in either product or process are likely to be difficult and expensive however this is not yet the case in the development of the wind industry in the US. Due to the late entry into the global wind energy ILC the US market is still seeing an influx of new actors and a build out of manufacturing facilities, implying that incremental product and process innovation is still occurring to adapt to the new setting.

The focus on quality/cost is essential for gaining legitimacy in the US, more so then in Europe, and the focus therefore becomes larger earlier on in an evolutionary perspective. The lack of feed-in-tariffs or other subsidies has made this development necessary in order to create demand and currently, while waiting for other incentives, the government funding from the DOE is directed specifically at cutting costs of the technology.

The table below summarizes the characteristics of the US wind industry in comparison to a typical industry development according to Utterback (1994). In general the conclusion can be drawn that the industry is in the growth phase which according to theory is characterized with an increasing rigidity to change. However with an increasing number of new entrants the US industry still provides space for both product and process change.

Table 18 Evaluating the phase of the industry according to Utterback (1994)

	US Wind Industry	Industry Development
Product	More or less standardized products with incremental innovations	From high variety, to dominant design, to incremental innovation on standardized products
Process	Quickly moving towards specialized equipment. However the need for skilled labor is still strong.	Manufacturing progresses from heavy reliance on skilled labor and general-purpose equipment to specialized equipment tended by low-skilled labor
Organizations	The influx of European actors provided more or less mechanistic firms from the start.	From entrepreneurial *organic* firm to hierarchical *mechanistic* firm with defined tasks and procedures and few rewards for radical innovation
Markets	Largely undifferentiated products with a focus on quality/cost improvements. However still somewhat unstable market due to policy uncertainty	From fragmented and unstable with diverse products and rapid feedback to commodity-like with largely undifferentiated products
Competition	An oligopoly of firms with similar products	From many small firms with unique products to an oligopoly of firms with similar products

7.2 Functional Analysis

The functional analysis is outlined according to Bergek et al's (2008) scheme of analysis where each of the seven functions is assessed separately. This section ends with a summary of the functions and their impact on the ILC.

7.2.1 Knowledge Development and Diffusion

This function maps the knowledge base including its evolution and its breadth and depth in order to identify its strengths and weaknesses.

The development of the large scale utility wind turbine was undertaken in Europe during the 1980's and 1990's and finally distributed to the US first around ten years ago. Therefore no natural knowledge development was undertaken in the US and the domestic knowledge base is still lagging behind Europe. However today when the market has grown substantially and public interest is rising the knowledge development is starting to catch up through federal, state and public initiatives and the future is looking brighter for this vital function. However an international trend that might hinder efficient technology and scientific development throughout the whole industry is the increased unwillingness of industry to collaborate with academia due to intellectual property rights and secrecy. In the US for example only the national laboratories have any substantial collaboration with industry and even they are articulating the increasing problem of secrecy within the industry.

The various types of knowledge development will now be analyzed in two categories; technical and manufacturing knowledge and project and maintenance knowledge.

7.2.1.1 Technical and Manufacturing Knowledge

As mentioned the R&D activities both within industry as well as academia has for a long time been focused to Europe and still researchers cannot point at an area were the US is ahead of Europe in terms of wind energy technology. However there have been substantial initiatives the last couple of years to change this development. Clusters of Universities are emerging to promote the development of wind and the NREL is performing projects together with turbine manufacturers. The ARRA solicitations have spurred technology development and as a consequence of some of these solicitations an increase in University collaboration has been witnessed. Further the largest turbine manufacturers on the US market, GE Energy and Vestas, have now opened up R&D centers in the US signaling a belief in the market and the potential for developing important technical breakthroughs in the US in the future.

Currently some argue that there will be an increasing need to develop a US specific knowledge base, where the extreme wind conditions are being carefully studied and the implication they should have on the future design of turbines. The design standards that have been developed in Europe function as a guideline for a turbine to achieve a 20-year life when operated under the conditions corresponding to the specific wind class. Although these standards are implemented in the US some argue that the classes should be extended to cover the US wind conditions better otherwise the risk of making the turbines too weak will lead to inefficiencies.

With an expansion of the current standards there is a need for new US specific turbine designs, leading the US R&D into a new more specified track of technology development. However before this can be done there is a need for a better understanding of the winds and the site suitability. At an AWEA event Gerard Hassan urged for better site suitability reports earlier on in the process and other have stressed that the current advances in Computational Fluid Analysis will soon make it easier to simulate the swirls and wake zones behind a rotor in order to better position the turbines in terms of power production

Finally during the years of extraordinary growth the supply chain was put under a lot of pressure and the industry realized that there was a need for a build out of the US based manufacturing capacity. Since the turbine manufacturers initially come from Europe they supply the market from overseas but that process is becoming inefficient and the industry is currently trying to build out the small domestic supply chain. The lack of supply-chain knowledge within industry has in some parts of the country, such as the state of Michigan, lead to an evaluation of suppliers to the automotive industry as a potential source of suppliers. However some skepticism is articulated regarding these suppliers' background but they still provide the best alternative to building up a completely new supply chain due to their long experience when it comes to manufacturing, documentation, services and keeping inventory which are subjects that need to be improved in the US wind industry.

7.2.1.2 Project and Aftermarket Knowledge

A strength of the US knowledge base lies within the experience of building large scale projects, in 2008 the average project size was 87 MW. The reason for this development is a combination of several factors; first and foremost the supply of vast scarcely populated areas is the prerequisite, but further there has been a consolidation among wind project developers to support larger orders, and increasing turbine and project costs while capturing the opportunities of economics of scale.

Since the bulk of the US installed capacity is still under the warranty period of the turbine manufacturer the development of a separate service sector with a sufficient knowledge base is still uncertain. Some concerns regarding the US project developers' slight resistance towards investing in maintenance, services and ad-on products, e.g. systems for condition monitoring, may decrease the speed of knowledge development within this field. Some argue that this reluctance is a consequence of investors' requirements on short pay-back periods. However some of the turbine manufacturers have recently started to see a change and say that the industry is increasingly willing to pay an extra premium for longer warranty periods and that the track record is of high importance to the project developer when choosing supplier implying more focus on knowledge development on this area since it can provide competitive advantages.

From industry organizations there is an increased focus put on the aftermarket, and during the AWEA Fall Symposium this was covered during many of the sessions with the main message that if the US continues to underestimate the importance of maintenance services and equipment the overall life time cost will increase and large expensive retrofit projects will be necessary. Faced with these future scenarios it seems as though project developers are becoming increasingly interested in maintenance services and the industry is trying to meet up with these demands.

One of these efforts is trying to provide skilled staff and in the last couple of years the US has seen an increasing number of colleges that provide education for wind industry service technicians. Together with their own training the manufacturers argue that there is currently no lack of skilled personnel however they are worried about the risk of losing their staff to project developers or independent service suppliers once the warranty period is over. Some industry reports, e.g. EERE 2009, though argue that the lack of skilled personnel and know-how will be one of the US industry's major bottle-necks in the future.

The general knowledge base and specifically the one for the aftermarket is therefore a hot topic and currently the industry is waiting for the next step to be crystallized; will the aftermarket knowledge develop towards independent service suppliers, project developers or turbine manufacturers. The only thing certain is the fact that currently the aftermarket is highly valued by the turbine manufacturers and they seem reluctant to give it away.

7.2.2 Influence on direction of search

This function aims at describing the incentives that exist for market entry as well as available guidance for US wind energy industry to predict and direct their business to meet future demands.

7.2.2.1 Renewable energy vision

The US political landscape has for many years been lacking a clearly stated vision for renewable energy. A reason for this are the 'political cycles' that has made the degree of support for renewable energy vary a lot between presidents and governments. During the 1990's efforts were made to alter the situation most importantly the introduction of the PTC in 1992 by President Bush. Although the PTC has been a strong driver for wind development its efficiency has been reduced due to the lack of sustainability, see figure 14 in chapter 5.1.

In addition, the US is lacking a globally communicated target for renewable energy similar to EU's goal 20-20-20; 20% renewable energy by 2020 (ec.europa.eu, 2010.02.08). This is important since the industry is global and there are currently other competing markets such as China and India, a federal RPS would change this. Furthermore when comparing the US energy politics to more "greener" European countries the main reasons for US politicians to promote renewable energy has not been about curbing climate change but rather about securing independent energy supply and creating jobs. By not signing the Kyoto protocol in 1997 US managed to quite clearly communicate that it will not lead the world towards a GHG neutral economic development.

The lack of a clearly stated, domestically and globally communicated, political vision for renewable energy have made both foreign and domestic actors hesitant to invest in the US wind energy industry. This has undermined the Influence on direction of search which has hindered an evolutionary industry development and still creates market uncertainty.

7.2.2.2 Institutional Change

During the last five years signs of an institutional change in favor of wind power can be detected in the US. Such signs include the feasibility study "20% Wind Energy by 2030" by DOE (2008) and the increasing public awareness of climate change which has allowed for greater political focus on the topic. The stimulus package, ARRA, showed proof of a stronger focus on renewable energy since it to a large part focused on creating "green" jobs. ARRA is also considered to account for the majority of the wind additions in 2009 through the extension of the PTC and the implementation of the ITC and the cash grants. However the default of the contemplated climate bill that president Obama aimed to implement during the fall of 2009 has again somewhat damaged the US intentions to become "green".

According to Umanoff, (18-12-2009) a shift occurred in 2007 that supports the notion of an institutional change, he believes it was the year when US finally embraced a policy commitment to renewable energy. At that point in time cumulated installed capacity was significant as well as the annual installations of 2007 and 2008. In addition, several large European utilities had entered the market and most of the large turbine manufacturers had announced that they were going to, or had already, established manufacturing facilities in the country. This showed belief in growth potential which further attracted large investors to finance wind projects in the US and actors within the supply chain to consider entering the US market which significantly strengthened this function.

The states with a RPS in place are also the states where most capacity has been installed. This shows the RPS's ability to function as a clear incentive for entering the market. AWEA as well as industry actors are currently focusing their advocating efforts on a federal RPS which would clearly state a national target and vision. However with the set-backs of the climate legislation a federal RPS seems unlikely to be in place any time soon. This is unfortunate and will have a negative impact on the Influence on the direction of search.

7.2.2.3 Articulation of demand

The majority of the wind installations are made by large experienced European actors or subsidiaries from large US utility companies; with such a strong group of customers there is a clear articulation of demand in terms of turbine designs and characteristics. The turbine sizes are continuously getting bigger as well as the average project size. Further experienced investors place high, clearly stated, demands on existence of track records and increased availability and performance standards which further guides the direction of search. AWEA functions as an important communication device since it through conferences and newsletters allows actors throughout the supply chain to communicate demand, technical expectations and expected demand. By having a clearly articulated demand the industry achieves a sense of direction which allows its actors to collaborate more effectively and efforts within R&D to be more focused.

7.2.3 Entrepreneurial experimentation

This function explores the IS's ability to reduce uncertainty measured by the number and the variety of new entrants as well as the breadth of technology applications within the industry.

7.2.3.1 Number of new entrants

The number of international turbine manufacturers active in the US has increased from five in 2005, (see fig 9 in chapter 4.4) to over ten who have announced intentions to or already established manufacturing facilities in the US. Included among the new entrants are also small actors, one particular example is Northern Power Systems who’s turbine is based on a different kind of technology which is a positive sign on Entrepreneurial experimentation.

The same situation is true for the number of component suppliers which is increasing, although the turbine manufactures are not satisfied with the speed of that development. Some of the component suppliers are coming from a background within the automotive industry despite some industry actors’ expressed skepticism regarding the ability of such suppliers to deliver good enough quality this should be looked at positively since it brings new knowledge and experience into the industry and thus strengthens the Entrepreneurial experimentation. There is a general positive outlook for the turbine manufacturing sector in the US and apart from 2009, due to the economic downturn, investments in the supply chain have continuously increased over the last years. Furthermore, the increased focus on buyer-supplier relationships to overcome shortages in the supply chain and to develop more specialized components strengthens the Entrepreneurial experimentation.

The number of project developers is also increasing and through ARRA the option to choose a cash grant in lieu of tax credits has allowed a broader variety of actors to finance their projects. A large part of the project developers are currently European but the number of US utilities is slowly but continuously increasing (see figure 11 in chapter 4.2). As more utilities enter the market a broader variety of experiences and processes are brought into the IS which will benefit the system.

7.2.3.2 Breadth of technology application and R&D

The breadth of the technology application can be considered to be quite limited. Most of the large turbine manufactures are sourcing from the same suppliers and offer similar kind of turbine sizes and turbine technologies. The investors’ and project developers’ demands on track records on performance and availability further seem to limit the search for revolutionary innovations however concurrently it spurs the search for incremental ones.

One specific characteristic of the US turbine industry is that the technology was developed in Europe and thus made to fit the European wind conditions. Quality concerns, including high failure rate of key components, might be explained by the US much stronger wind and weather conditions. To lower the failure rate the technology needs to be adapted to US conditions and currently several of the large turbine manufacturers have established R&D centers in the US, such as Vestas in Colorado, GE in the state of New York which is a positive sign.

The national laboratories NREL and Sandia are two of the country’s leading facilities for wind research. Through ARRA these laboratories, as well as other industry and university R&D initiatives, have received funding. The outcome of that research is still unknown but the overall increased spending on R&D in the industry is likely to have a positive effect on the wind technology development in the US and the overall IS.

7.2.4 Resource Mobilization

This function investigates how the growth of the IS is supported by an influx and build up of human and financial capital as well as complementary resources.

7.2.4.1 Mobilization of human capital and financial capital

Looking at the mobilization of human capital no industry actor has expressed a shortness related to human resources, though a request for more industry know-how and experience has been articulated. Manufacturing workforce has been made available due to the downturn in the automotive industry, especially in the states of Michigan and Ohio. However, as the industry continues to expand the industry know-how and access to specialized workforce must be improved, training and educating workforce are thus of high importance in the future.

When it comes to service technicians there are a variety of programs ongoing at both national and local levels. These include state colleges and training programs by turbine manufacturers and have resulted in an increased amount of service technicians. Through ARRA more resources have been placed on educating and training workforce. However, there seems to be few technicians who can manage several types of turbine brands. With a majority of US turbines still under warranty period it is the turbine manufacturer who does the service. A large wind farm containing different turbine brands is therefore serviced by several service teams, one for each brand. This seems both inefficient and expensive and contributes to a lower degree of learning and knowledge diffusion which weakens the Resource mobilization.

Financial resources are in this report mainly looked upon as project financing. The structure of the US energy policy has made the industry dependent on tax equity investors to be able to monetize the tax credits. As the tax equity market was hit hard during the economic downturn the whole industry felt the effect as the number of tax equity investors went from twenty-five to zero. As the economy picks up some of them have returned however the uncertainty regarding if it will happen again in a future recession remains. The number of turbine manufacturer offering vendor financing is expected to increase but the lack of private investors will continue since due to US tax rules private investor ´s cannot benefit from tax credits.

7.2.4.2 Mobilization of complementary assets

Since the development of the US wind industry has not been evolutionary but rather happened quickly during the latter half of the last decade, the development of complementary assets has not yet been able to catch up. The major default is the alarming lack of sufficient transmission lines throughout the country. Today the industry, with AWEA as a strong force, is advocating for more transmission to be built. Though with increasing push back from incumbent energy producers together with a lack of an efficient federal regulatory force for building transmission lines this challenge is likely to remain.

Due to uncertainty caused by the unstable development of the wind energy industry a domestic supply chain has never been fully developed and still suffers from underinvestment in manufacturing capacity of both turbines and components. This has made the industry reliant on import of such goods which during the strong growth in 2007-2008 caused a shortage of supply of almost all types of key components. With the recent economic downturn the industry had the opportunity to reorganize its supply chain and more emphasis has been put on supplier relationships strengthening the Resource mobilization.

Regarding services, an efficient Mobilization of resources has neither taken place and though the cost of maintenance has decreased historically it is estimated to increase again as wind farms grow older. Though the O&M market is inefficient it is considered to have strong potential for growth as more actors recognize the revenues that can be caught within this field. No “standardized” way of structuring O&M around large wind farms has yet been crystallized and it is uncertain who will perform the services in the future and different types of strategies are expected within this field.

To be able to cost efficiently support the expected growth of the industry there is a need for a strengthen Resource mobilizations within all fields from transmission build out to growing the domestic supply chain including services such as construction, transportation, legal, financial, safety, and O&M services.

7.2.5 Market Formation

This function describes actual market development as well as identifies the main drivers behind the market development.

The wind energy market in the US has grown at an extraordinary speed during the last years which has enabled the market to quickly evolve into a mass market. Interestingly it seems as though the learning space, as described by Bergek et al (2008), is somewhat lacking for the US market and that the nursing markets mainly occurred in Europe. When the technology was more or less readily developed it was transferred and diffused to the US market and thus a bridging market was created from the start where volumes could increase and the IS could be enlarged through the entrants of new actors.

7.2.5.1 Actual Market Development

The growth of installed capacity in the US boomed during the years 2006-2008 with growth rates around 40% and although the market was expected to slow down during the financial downturn the industry saw an increase on newly installed capacity in 2009 that actually surpassed the previous record breaking year. The total accumulated installed capacity has now reached 35,159 MW including the 9900 MW that was installed in 2009.

Interesting is also to point to the differences between states and the installed capacity. Currently there are 36 states in the US with utility scale wind farms and 14 states with more than 1000 MW installed. California which is known for its early efforts within "green" solutions and which was one of the first states to install wind turbines during the 1980's is currently still ranked third in the US but the state has not experienced much growth the last couple of years. Surprisingly Texas is the state leading the installed capacity and it provides a good example of the importance of an efficient policy framework.

Further it is also of importance to highlight that the market development in the US has been characterized by large sized wind farms and that the sizes of the project seem to still be increasing. The figure 13 in chapter 4.2 illustrates the average size of wind farms and shows the tendencies of the growing sizes. The increased size of projects is driven by the; growing demand for wind, increased size of turbine orders, consolidation among wind project developers to support larger orders, and increasing turbine and project costs which promote capturing of opportunities of economics of scale.

7.2.5.2 The Drivers of the US Market

Identifying the drivers of wind energy is rather complex and very much interlinked with external forces outside of the actual wind IS. For example the main driver for wind development is policy initiatives however the bulk of these tools are not specifically directed to wind but rather included in a larger political effort of creating demand for renewable energy. Further the lack of sufficient transmission will have a substantial influence on the development of wind energy in the future.

However one of the most important drivers of installed capacity in the US has historically been the PTC. Active since 1992 with a on again off again pattern it has been shown that the years when the tax credit was not renewed the new installed capacity dropped significantly (see figure 9, chapter 4.2). With the introduction of the ITC and the cash grants, under ARRA, the decline expected during 2009 seemed to have been avoided. The impact of these tax credits is so large that some argue that there would be no substantial amount of wind installed in the US without these benefits.

The state renewable portfolio standards (RPS) have also shown to be an important driver for wind energy, basically creating demand from utilities since it obliges them to purchase electricity from renewable energy source. The states with the highest installed wind capacity all have a state RPSs in place and the next important step for wind energy would be making sure that a federal RPS can be put in place.

Up until now these two policy initiatives, tax credits and state RPS, have driven the market and they are still much needed for wind to continue to expand. However as wind energy continues to grow the competitive environment will strengthen and larger energy market forces will come to play an increasing role. Already today the effect of inefficient transmission has led to curtailment in states such as Texas and the anticipated build out of the transmission in Texas, and other states, will most likely act as an important driver once announced. Still these issues are far from finished and many argue that the build out of a federal transmission infrastructure will come as a consequence of a federal RPS which then leads back to policy as the most important driver.

7.2.6 Legitimacy

The function aims to evaluate the strength of the legitimacy of the technology as well as the factors influencing the legitimacy.

In the US the climate change issues have recently started to gain greater public awareness with influential public spokesmen, e.g. Al Gore and the President Barack Obama, strongly advocating for a change in the country with the world largest energy consumption. Wind energy as the most reliable renewable energy source is however still facing some large hurdles before the legitimacy of the technology is approved.

There seems to a strong interconnection between public acceptance and the political focus in the US. Currently the democratic majority, some say, have emphasized the differences between republicans and democrats, with the former pushing its agenda to the furthest hence driving the interest apart. The current strong difference between party lines makes any political act hard to realize and divides not only congress's interests but also the public's. Some argue that what is needed for a climate and energy bill to pass is a strong bipartisan support like the Kerry-Lieberman-Graham framework which includes incentives for other types of energy sources as well. However such an proposal would not be as efficient as some of the other initiatives when it comes to strengthening the position of renewable energy and thus not providing the type of legitimacy needed.

The current strong bipolarization of the US divides the public into different mind sets and causes a great deal of disbelief and confusion in questions related to wind and renewable energy. The positive side to this equation is however that a strong republican disbeliever in climate change can still promote developing renewable energy for the cause of energy independence and job creation.

This function will now be divided and discussed through three perspectives, the legitimacy gained from the political strengths, the public acceptance and from the technology.

7.2.6.1 Political Strength

The Obama administration gave new hope to the climate and energy debate in the US and already in June 2009 a new climate and energy bill was passed through the House of Representative which raised the hopes for all types of renewable energy sources. However the initiatives in the Senate have failed to gain the same momentum and it is very unlikely that a bill would pass any time soon, or include the necessary federal RPS that would help the wind energy industry in the short term. Some argue, like previously discussed, that there is a need for a bipartisan approach but there are many environmentalist groups and organizations that would not be pleased with such an agreement since it would have less of an impact. What AWEA is advocating for specifically is an aggressive short term RPS of 10% by 2012 with a long term target of 25% by 2025. A federal RPS, as communicated by AWEA, is essential to ensure the rapid deployment of renewable energy in the US. Since only one of the initiatives in the Senate include a RPS it sends the message that the most important issue right now is not to promote renewable energy technology but rather to get green house gas emissions down through a cap and trade scheme.

Although no new climate legislation is likely to pass anytime soon the enactment of ARRA provided a lot of new incentives for the wind industry and signaled an increased importance of renewable energy in the President's agenda. The most important being the prolonging of the PTC together with the introduction of the ITC and the cash grants. These tax incentives which AWEA argue should be included in a federal tax law in order to level the playing field with other energy resources.

The most important political efforts for renewable energy and wind have therefore up until now been done by the individual states by implementing policies such as RPS and REC markets that have been proved to work even in oil rich states such as Texas. For renewable energy to gain greater political legitimacy in Congress a strong bipartisan approach is needed and for such an initiative to include a federal RPS Texas and other RPS success stories will need to be further highlighted by lobbying organizations.

7.2.6.2 Public Acceptance

Since there is no such thing as the average American it is hard to gain a general understanding of the opinion on wind energy and it seems to vary greatly from state to state often accompanying the party elect. However most of the industry actors interviewed seem to agree upon the fact that the opinion of wind energy in general is positive but the main problem seems to be that the public does not want to see, hear or have the actual wind towers near their house. This type of opposition is so common that it has gained a nickname NIMBY, Not In My Back Yard. In state such as New York and Massachusetts the NIMBY resistances together with ineffective state permitting processes have made it increasingly hard to build projects in these regions although the general public opinion is very favorable towards renewable energy.

On the other hand it has been shown that public acceptance for building new projects can be gained through small scale initiatives such as the one from Cliff Ethereridge and the case of the Roscoe wind farm. In a region which has been one of the most important oil regions in Texas a cotton farmer managed to mobilize over a 100 landowners for a project that became one of the largest wind projects in Texas, see the example in chapter 4.2. The role that Cliff Ethereridge took on is today recognized as a land agent and it has becoming increasingly important for developers to have one of these people on board in order to navigate the local regions.

Although the general public overall seem to be positive towards renewable energy there is at the same time a strong skepticism regarding if it is actually viable in a economic sense and if it is a trustworthy source of energy. Many of the opposing industry organizations such as The Industrial Wind Action organization and the National Wind Watch take it one step further arguing that the effectiveness of wind in terms of reducing emissions is limited as is its impact on environment, economy and quality of life. As one interviewed developer put it the opposition always screams the loudest and in the end so might also the case of wind energy be.

7.2.6.3 The Legitimacy of Technology

As mentioned one of the largest threats to public acceptance for wind is whether or not the technology can carry itself economically. Due to the historic factors, such as the US great reluctance towards subsidies and the short termed investment horizon, these issues are of greater importance then in Europe.

Technology development is currently very much guided by reducing the cost of the overall project. The issue of maintenance for example is gaining greater acceptance due to the fact that neglecting these issue may lead to large scale retrofits, reduced profitability and ultimately reduced attractiveness of the industry. Further siting issues are also closely interlinked with this since site suitability has a great impact of the availability and effectiveness of the turbines.

But one of the most important technology development currently researched are the costly high failure rates of gearboxes. These key components tend to break up to ten times as often as other components and are thus one of the greatest influences of turbine downtime in the industry. Further the size of the blades are currently hindering the development of larger turbine sizes that can leverage economies of scale and a lot of research is put into the development of lighter more efficient blades that would reduce the costs through extracting the maximum amount of power from the wind.

Further technology development efforts like these, which currently gain support from the ARRA funding, will help the industry to become more cost efficient and the technology to gain reliability and ultimately public acceptance.

7.2.7 Development of positive externalities

This function investigates the positive and negative feed-back loops derived from all of the other functions described in this chapter.

The US wind energy industry has experienced a series of positive feedback loops leading to the extraordinary growth during the last five years. However the path of the development has also been characterized by negative feedback loops which explain why the industry, in comparison to Europe, took so long time to change gear and enter a significant growth face. The figure below shows the positive feedback loops as well as the influence of an historic negative feedback loop on the IS.

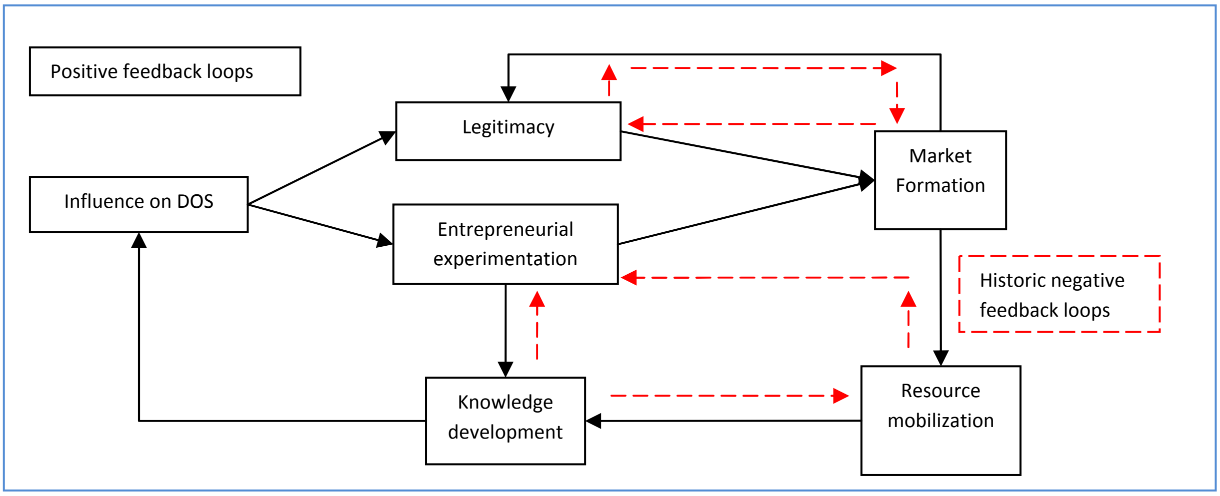


Figure 26 Positive and Negative Feedback Loops within the US Wind Energy Industry IS

The development of positive externalities was not initially due to a high number of new entrants as theory suggests (Bergek et al, 2008), instead it was a number of few but strong actors who created an articulation of demand towards utility scale wind farms and turbines. Together with incentives to enter the market in the form of increased political legitimacy, PTC and state RPSs, the increased Influence on the direction of search attracted more actors to join the industry in the mid 2000's. New entrants strengthened the Entrepreneurial experimentation and the breadth and variety of actors in terms of both customers and turbine vendors which finally enabled the Market formation to enter into a strong growth phase. With large actors driving the demand together with a significant institutional change in 2007, with the passing of the 2007 Energy Independence and Security act and the issuance of the *"20% wind by 2030"* report, strengthened the overall Legitimacy of the industry.

However historically the lack of a long term sustainable policy program, with the on-again-off-again patterns of the PTC and a lacking political vision, provided little incentives for entering the market as well as poor legitimacy, and explains the poor Market formation during the 1990's up until around 2005. As a consequence little investments were made on a domestic supply chain and the overall mobilization of Resources, especially transmission and human resources, was weak. Together with a historically low degree of Entrepreneurial experimentation a broad Knowledgebase and industry knowhow were never developed and is still somewhat lacking. However with increased spending on R&D and an increase of new entrants the situation is improving.

The lack of complementary assets is still hurting the industry by making it less cost efficient than it could be. Together with the transmission uncertainties this weakens the overall Legitimacy of the industry. Going forward the increasing number of entrants will spur the growth of the supply chain and through joint advocacy efforts the transmission situation will improve, however the lack of a clear political vision, e.g. a federal RPS, will continue to prevent the Influence on direction of search to blossom and the Legitimacy to remain uncertain.

7.2.8 Summarizing the Functions and their impact on the ILC

The functions analyzed are summarized in the table below. The table divides the negative and the positive impact of each function on the overall innovation system. This chapter further examines the importance of each function in the development of the innovation system.

Table 19 Summarizing the functions and their impact on the IS, the arrows show signs on improvement

Function	Negative Impact on the IS	Positive Impact on the IS
Knowledge	• Still lack of collaborations → • Poor fundamental knowledge base, currently improving • Weak knowledge within design and aftermarket	• Increasing collaborations between supplier and buyer • Increasing number of R&D facilities
Influence of DOS	• Historically lacking political vision → • Policy uncertainties • Pushback from incumbents	• Ongoing institutional change, including state RPS & ARRA, are signs on improved political support • Strong articulation of demand by leading customers
Entrepreneurial experimentation	• Technical application: not broad for turbines technology	• New entrants, strong growth during last 5 years • Increasing spending on incremental innovations and improvements, related to both services and products
Market Formation	• Lack of nursing market • Policy uncertainties	• Strong growth last decade led to direct development into mass market • Drivers of market development: Tax credits, RPS, access to transmission, lowering cost of wind energy
Legitimacy	• Political legitimacy low due to political cycles, although strong at the moment → • Problems with NIMBY's and the influence of anti movements • Concerns regarding the quality of technology and the need for adaptation to US specifications	• Public acceptance generally high concerns regarding costs & turbine failure • Technology is proven due to maturity
Resource mobilization	• Human capital: future bottleneck • Financial resources are key, dependent on tax equity investors • Complementary assets are lacking, e.g. transmission and supply chain	• Increasing amount of manufacturing facilities • Increased focus on training programs both from industry, academia and DOE
Positive Externalities	• The overall resource mobilization waited due to the uncertainties regarding political initiatives and an industry knowledge base and supply chain never fully developed • Market took long time to develop due to policy uncertainties	• Few strong actors lead the initial Market Formation and from that followed Entrepreneurial Experimentation and the build out of networks gaining Legitimacy for the industry • The current lack of complementary assets are now driving the development mobilizing strength in Entrepreneurial Experimentation and Knowledge Development

In the specific case of the US wind industry due to the lack of an embryonic stage the development of the IS can be divided into three growth phases; initial, accelerated and future. A greater influence of Direction Search set off the initial growth period during the early 2000's. This included the increased state initiatives in the form of RPS which not only enhanced the legitimacy but also created an initial demand for renewable energy. During the years 2001-2004 a majority of the state RPS that are available today were implemented and when the PTC was reinforced in 2004 they together lead the Market formation.

From the years 2005-06 up until today the industry has experienced a phase of accelerated growth in terms of installed capacity. With the influx of actors the mobilization of resources became of greater importance and the initial build up of a supply chain was witnessed together with a greater interest from investors. The move of large European utilities onto the US market increased the influence on Direction of Search further at this stage and it was first now, when demand had been articulated to a larger extent, that the Knowledge development became increasingly important. Industry emphasized the importance of a more efficient cost/quality technology development and the historic lack of institutions focused on R&D forced a larger mobilization of the universities and national labs to support this development. Finally the role of the PTC, and now also the ITC that was issued under ARRA, have continued to be proven strong forces for development and increases Legitimacy.

Moving forward into the next phase of future growth legitimacy will most likely continue to have an important role, although its development is quite uncertain, together with further resource mobilization. For the industry to gain strength a larger knowledge development together with an increased entrepreneurial experimentation will also be of importance for necessary future technology adaptations. The picture below summarizes the functions that have primarily driven the growth of the industry in each phase as well as points to which functions that may be of greater importance moving forward. In the next chapter these forces influencing future development will be analyzed through the identification of inducement and blocking mechanisms.

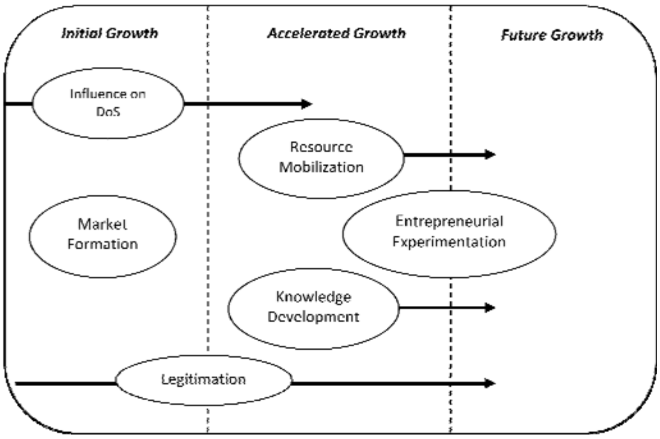


Figure 27 Overview of the IS's different phases

7.3 Identifying the Inducement and Blocking Mechanisms of the IS

To conclude the functional analysis this chapter will explore the inducement and blocking mechanisms within the industry. Such mechanisms are those that either hinder or push the market development and thus the industry's ability to move forward.

The picture below provides an overview of the inducement and blocking mechanisms identified in the functional analysis.

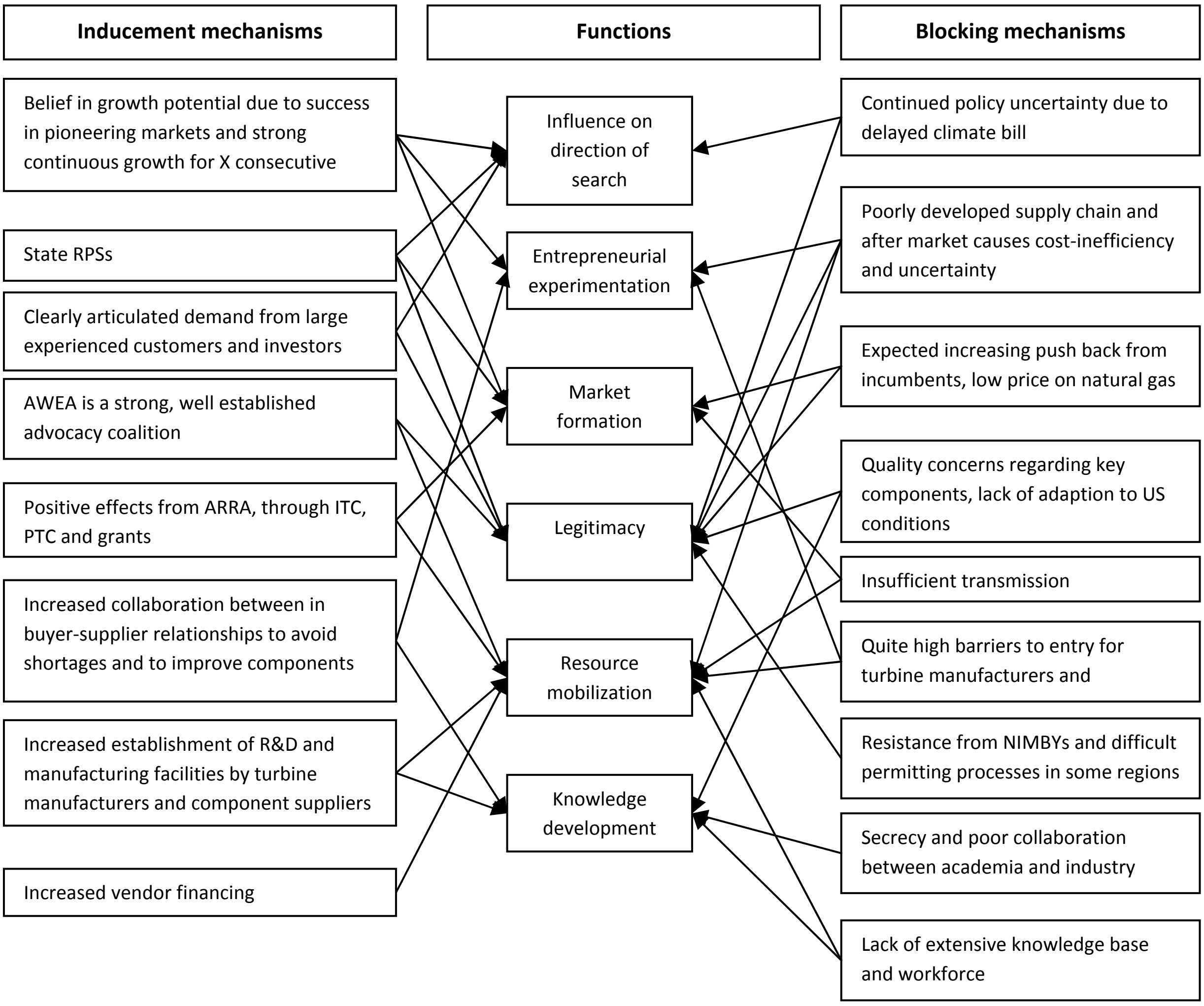


Figure 28 Overview of Inducement and Blocking Mechanisms

There are several both inducing and blocking mechanisms that are shaping the functional pattern of the IS. In order to get a better overview these mechanisms have been clustered together into four positive inducing forces and three negative blocking forces starting with the positive forces;

1. ***High expected market growth:*** States such as Texas with an efficient policy environment, e.g. state RPS, have proven the concept viable in terms of cost competitiveness on a utility scale basis. Together with a decreasing cost of technology and stronger political legitimacy the belief in growth potential is strong spurring a larger demand for wind turbines. The few strong actors that

have been leading the market through the previous decade have through a clearly articulated demand given the industry a sense of direction and an informal standardization consisting of large scale projects and turbines. All together this has created an attractive industry with strong belief in growth potential which has attracted an increasing number of new entrants.

2. ***Increasing investments in the supply chain:*** The previous decade has seen increasing investment in the supply chain as well as in R&D. As of today most of the global turbine manufacturers have established, or announced, manufacturing facilities in the US and several also have R&D centers. Concerning component suppliers, the development of a domestic supply chain has been slow but it is currently expanding, and the turbine manufacturers are encouraging their suppliers to enter the US market. This dedicated, long term effort made by the turbine manufacturers to mobilize a large scale supply chain signals a future belief in the market and thus creates market legitimacy.

3. ***Strong industry networks:*** Together with the growth of the industry local and national networks have been strengthened with AWEA as one of the main drivers. Through these networks industry collaborations, such as buyer-supplier relationships, are promoted creating knowledge diffusion and business opportunities. AWEA further functions as an important advocacy force influencing policy through articulating the industry’s demand and strengthening the legitimacy of the industry.

4. ***Increased industry legitimacy:*** There has lately been an increased focus on renewable energy by the US government. Initiatives such as ARRA and the increased recognition of climate change by the Obama administration have provided stronger political legitimacy for renewable energy. The political legitimacy has further been induced by successful implementations of state RPSs which also drives demand.

Concerning the blocking mechanisms of the industry the following have been identified as the most influential;

1. ***Policy uncertainties:*** Despite stronger political focus on renewable energy the recent failure of adopting a larger climate and energy legislation, with a much needed federal RPS, provides uncertainty for the future development. Considering the historical unpredictable enactment of the PTC the future beyond 2012, when the current tax credits and the cash grants expire, provides additional uncertainty for project developers. The policy uncertainty, together with a push back from incumbents and a decreasing natural gas price, further provides an unfavorable position for the industry since without tax credits wind power cannot compete effectively in the energy market. Legitimacy is also damaged from disadvantageous permitting processes in some states caused by ineffective legislative procedures and NIMBY’s.

2. ***Poorly developed knowledge base:*** There is a lack of a fundamental knowledge base within the US industry. With quick installations of European turbines, shortage in supply and seemingly little knowledge about the US specific wind conditions high failure rates of turbine components has come as a consequence. Currently a need for technology adaptation to the US market is articulated however with a lacking knowledge base solving these issues it might be difficult and take longer time than necessary. Additionally the lack of collaborations between academia and industry, due to high secrecy, prevents efficient knowledge diffusion.

3. ***Lack of complementary assets:*** The most prominent concern within the industry to support further growth are the under developed complementary assets. Firstly a domestic supply chain is still

largely lacking causing big problems with lead times etc. Due to high technical requirements and a somewhat consolidated market the barriers of entry for new turbine manufactures and component suppliers are considered high preventing a quick build out of the supply chain. Furthermore the cost of maintenance is high due to underdeveloped service market. This was caused initially by the unwillingness of US project developers to invest in maintenance. Though this situation is changing towards a larger focus on such services the aftermarket is underdeveloped and uncertain in terms of structure and actors. Finally one of the greatest constraints moving forward is the lack of sufficient transmission that is literally hindering the build out of wind power in regions with great wind resources. This issue is difficult to solve due to the complexity of the infrastructure and the lack of federal legislative forces.

Concluding this analysis of forces affecting the industry the expected future growth is by far the most important positive one. The other inducement mechanisms can be seen as natural trajectories from this strong force implying that the build out of the supply chain and supplier-buyer networks follows a general growth of the industry. However these expectations are somewhat overshadowed by the current policy uncertainty and the lack of necessary complementary assets, primarily transmission.

7.4 Identified opportunities within the US wind energy industry

This chapter will investigate the opportunities for Swedish firms to enter the US wind energy industry. The analysis is based on the structural conditions of the industry posed by the inducement and blocking mechanisms identified in the previous chapter.

To begin with, the inducement and blocking mechanisms identified in the previous chapter should not only be considered in a positive versus negative light as one might think. As an example, an inducement mechanism, such as the extension of the PTC through ARRA may be a positive opportunity for the industry but for a Swedish firm it may be an obstacle since it requires the firm to establish a US subsidiary to benefit from such tax credits. Vice versa, a blocking mechanism such as the poor academia-industry collaboration may be negative for the industry but positive for a Swedish firm who has experience from such collaboration in Sweden and can thus use that knowledge to organize such collaboration in the US. The following analysis is based on this type of reasoning.

Three major areas of potential opportunities have been identified; Component supply, Services and Electric infrastructure, according to the picture below. Each of these will be described and discussed individually in the following section. Additionally, even though it is outside the scope of this report, it is worth mentioning that indications of opportunities within composite materials, large forgings and castings have also been spotted based on the lack of such competencies on the US market. There are also opportunities for project developers on the market, especially with the implementation of the cash grants through ARRA, however neither these opportunities are within the scope of the report.

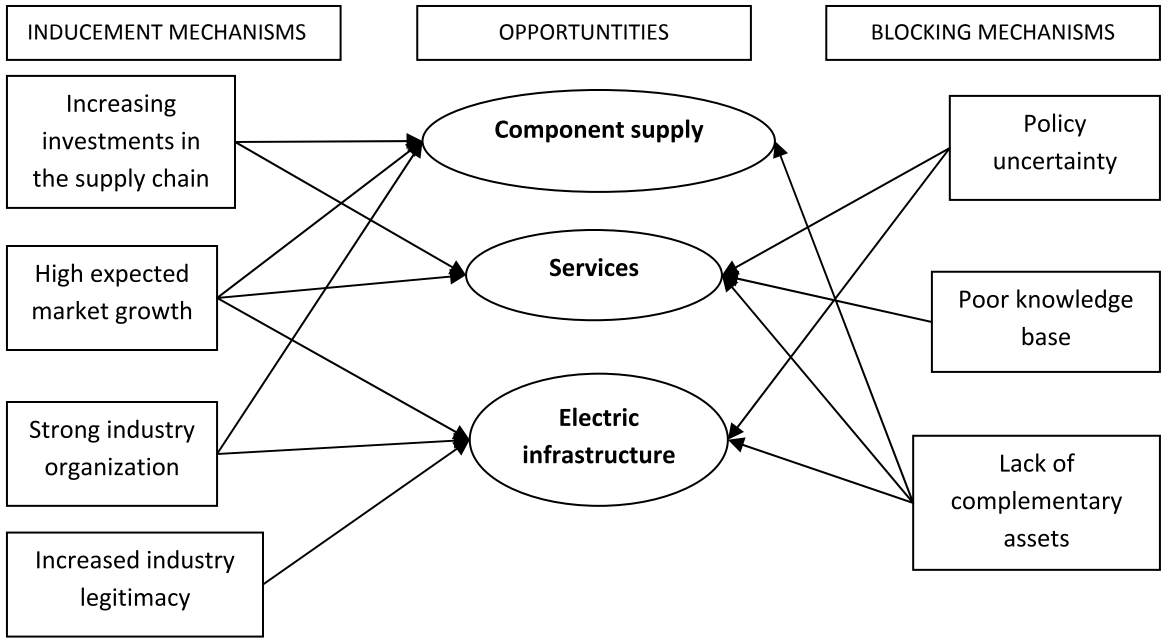


Figure 29 Overview of Opportunities within the US Wind Energy Industry derived from blocking and inducement mechanisms.

7.4.1 Opportunities related to component supply

The long term opportunities within the component supply chain are foremost driven by the high expected market growth and the increasing presence of turbine manufacturers in the US. The currently underdeveloped state of the supply chain poses as a blocking mechanism for the overall industry but an apparent need for a build out is articulated within the industry thus creating business opportunities. The increased investments in the supply chain confirm this observation.

The turbine manufacturers have an articulated wish to reduce risk and costs concerned related to the lacking domestic supply chain such as shortages in supply, long lead times, exchange rates and transportation. The largest risks are associated to key components where there are currently few suppliers located in the US. High failure rates for key components, especially gearboxes, have spurred demand for local options to avoid long reparation lead times. Further the demand of local sourcing options for blades and heavy components are driven by quality and cost risks associated to transportation. The costs of moving equipment from Europe is increasingly prohibitive and is directly effecting the prices. Now even the costs associated with moving larger components are beginning to outsrip the labor cost differences between North America and China & India. Therefore the market is driving companies to manufacture, assemble and install turbines closer to points of manufacture. Every fuel price increase however small diminishes the competitive abilities of non-North American companies especially in manufacturing. (Chapla, 01-02-2010)

In order to catch these opportunities a supplier need to overcome certain barriers of entry. The increasing need for more sophisticated key components might be an opportunity for a firm with strong technical competencies, however much knowledge and experience is needed to be able to adapt the technology to US specific wind conditions. The strong wind conditions might make technology used for offshore wind turbines appropriate for US onshore wind farms. Further, due to the high failure rates, component suppliers need to possess a strong track record. Establishing such a track record is tough but not impossible since experience is transferable from one business sector to another and according to Chapla (01-02-2010), involved with economic development in Michigan, most wind turbine manufacturers looking to expand a supply chain also give that factor some consideration. The scale and size of utility size turbines and large orders for large wind projects often requires major capital equipment outlay, it also takes time to build procurement relations as well as contract orders that are large enough to amortize capital expenditures. Due to deadlines posed by expiring tax credits being able to deliver on time is crucial within the industry and has a strong effect on a supplier's track record.

Suppliers already involved with the wind industry in Europe will, quite obviously, have a strong advantage moving to the US. Some European turbine manufacturers, such as Vestas, are encouraging their suppliers to come with them to the US. With increasing requirements on technology, for actors previously not involved with the wind industry the largest opportunities probably lie within second tier supply. However important to mention is that the although European OEM's might still have a strong advantage in the North American market their position is now being challenged by other emerging OEM's from China and India, whom are both well capitalized financially as well as in terms of human resources (Chapla 01-02-2010).

In the US, most manufacturing knowledge exists in the "rust-belt-region" including states like Michigan and Ohio where the long tradition of an automotive industry has built up a supportive infrastructure. However the automotive industry is not the only potential industry expertise when it comes to expanding the US wind supply chain, i.e Chapla (01-02-2010). also mentioned the West Michigan furniture industry as a potential future skill set that could be transferable to the wind industry. Due to the recent economic downturn excess capacity of workforce and other resources currently exist in these regions as well as economic development centers to support and promote establishment of new manufacturing businesses. This region therefore poses advantages for component suppliers looking to locate manufacturing facilities in the US. When the economy returns, for a second tier component supplier, this region also poses opportunities to supply to other industries as well. However as turbines grow larger, the costs and challenges of moving large components within the country is difficult and expensive, therefore developing a supply chain closer to the end placement, i.e. the most important wind regions, may be a great competitive advantage according to Chapla (01-02-2010).

7.4.2 Opportunities related to services

The lack of complementary assets drives demand for increased supply of services on the market. The need is augmented by the expected strong market growth, a significant amount of already installed capacity and an increasing amount of turbines coming out of warranty periods. This sector therefore poses several potential opportunities both in terms of aftermarket services and installation services.

There is an outspoken demand to lower cost of maintenance and making the aftermarket sector more cost efficient. As turbines grow older the cost, and need, for maintenance is likely to increase. Together with the US industry's poor knowledge base and inexperience of long term operation and maintenance of wind projects the opportunity grows larger, especially for European actors with much experience. With the aftermarket not yet crystallized there are important first mover's advantages to pursue, however there are obstacles to enter the market.

Regardless of boosted efforts from academia and industry to provide service technicians, hiring personnel with the right competencies and expertise is expensive and may be difficult to come by in the US. Therefore there would be a need for extensive training and education programs which requires collaboration with the turbine manufacturers. Getting that access might pose a challenge since increasing number of turbine manufacturers have declared stronger efforts on the service market and may therefore be unwilling to promote competition within this sector, i.e. allow competitors full access to technical information. However the European culture of quality and optimized maintenance would pose advantages compared to domestic third party service suppliers.

Similar to the supply of components there is a vast need for quality and cost control as well as track records proving success within these fields. Track records are especially important for construction firms who without it would not be eligible due to turbine manufacturers' unwillingness to grant warranties to project developers using unqualified construction firms. With the expected growth of wind installations and need for service and maintenance, including retrofit projects, the demand for crane services will also increase. The opportunity here lies within both providing the service and the supplying the actual cranes.

Despite US project developers' historical reluctance to invest in add-on services and products, e.g. condition monitoring systems, increasing demand on project performance might open up for new opportunities within this field. Further, a larger presence of European project developers may strengthen this opportunity since they are traditionally more prone to invest in complementary products. Such add-ons may include better monitoring of wind conditions, improved met-towers, site assessment services, and quality monitoring systems. This sector creates space for technical, innovative products and services, together with a weak US knowledge base, foreign actors may have an advantage here. Another sector which there has so far been little focus on within the US industry is safety and Vestas has recently called for more focus on the matter. As the industry matures policy uncertainty caused by potentially stricter rules and regulations might spur demand for services and products within this field.

7.4.3 Opportunities related to electric infrastructure

To meet the expected strong market growth, the blocking mechanism posed by lacking complementary assets concerning transmission infrastructure needs to be dealt with. Despite uncertainties, increased political attention on the matter together with AWEA's strong advocacy efforts and increasing overall industry legitimacy provide hope for a solution which would imply opportunities within electric infrastructure products and services. Further due to US's historically little focus on electricity infrastructure the country lacks the right competencies and resources for a major build out which further enhances the opportunity for foreign firms.

When a build out of the system will take place, both in terms of new transmission lines and general system upgrades to a smart gird, there will be a large demand of electrical components, solutions and services. In some states, especially Texas, CREZ projects and other privately funded projects, e.g. the NextEra line, might provide opportunities earlier, but a larger build out is unlikely to occur within the next two years.

With limited transmission grid owners can place higher demands on project developers to improve project interconnection efficiency. Together with intentions to lower interconnection costs this provides opportunities for suppliers of electrical components within the turbine, or within the wind farm.

7.5 Considerations when entering the US wind energy industry

This discussion aims at combining the key success factors in the Swedish Biogas International (SBI) case, presented in chapter 6.2., with the structural conditions of the US wind energy industry in order to give recommendations to firms who wish to enter the industry including how to overcome the main barriers to entry.

The table below summarizes the main barriers to entry of the US wind energy industry; these are derived from the three opportunities described in the previous section.

Table 20 Summary of the Main Barriers to Entry to the US Wind Energy Industry

Main Barriers to Entry

1. Difficult to get recognized by the large turbine manufacturers as well as project developers especially for small, new, suppliers, i.e. getting by the 'gatekeepers' at the OEM's procurement departments
2. Need for quality and cost control as well as track records proving success is difficult to come by, deadlines posed by expiring tax credits also makes it crucial to be able to deliver on time
3. Knowledge and industry know-how is needed to adapt the technology to US specific wind conditions, hiring personnel with right competencies is expensive and may be difficult to come by in the US
4. Need for extensive training and education programs, requires collaboration with the OEMs, getting that access might be difficult
5. Scale and size of turbines and projects often requires major capital outlay, it takes time to build procurement relations and get orders large enough to pay back capital expenditures
6. Reluctance by US project developers to invest in add-on products and services makes it difficult for new actors to create demand, and also requires such products and services to be cheap

With the wind industry becoming increasingly globalized companies should take a globalized perspective when contemplating entering the US wind industry and the strong industry build out in China enhances global competition and may pose future threats. Further, large globalized customers such as Vestas, GE, Ibedrola and project developers are likely, due to their size, to have strong bargaining power. However, due to the underdeveloped domestic supply chain, domestic suppliers currently have strong bargaining power which may present first mover advantages for suppliers who in the near future decide to move to the US. Harding (21-10-2009), business consultant, believes that there is currently a window of opportunity on the US clean tech market that will last for about 3-4 years, when to enter the market is therefore a question of high concern.

The general barriers of entry into the US are few; restrictions and limitations are small and as long as a supplier decides to establish a subsidiary in the US it can partake in the governmental policy initiatives. It is therefore important to consider political benefits when deciding in what state to locate in, within the wind industry this is perhaps even more important since energy and tax policies may vary significantly between states. In addition, both at federal and state level solicitations funded by the stimulus package, ARRA, may be available. These are also open for foreign firms and may be a great way to enter the market (read more on www.recovery.gov). The most preferable state or city to establish in also depends on the company's service or product and weather heavy manufacturing is needed. In general states with supportive policy and existing transmission for large installations of wind power are probably best suited for service companies, the same might be true for component suppliers however manufacturing advantages in the north eastern states should not be underestimated. If R&D is important states like Colorado where NREL is located should be of interest.

In the case of SBI utilizing networks was essential; the transfer of technology and business between Sweden and US is often based on initiatives taken by politicians such as state governors or Swedish regional politicians. Catching such opportunities, like SBI did when governor Granholm came to Sweden, is highly valuable, joining clusters and networks in the home market increases the chance of getting such recognition, an example of such a network present in both US and Sweden is the Swedish American Chambers of Commerce (SACC). In the case of SBI, the Michigan Economic Development Center (MEDC) posed as an important network and collaborator and such organizations seems to be increasingly common in the US. An important parameter when deciding where to locate in the US is therefore the presence of such networks, a specific example is The Right Place an economic developer in Michigan who one and a half years ago established the West Michigan Wind Manufacturing Network (Chapla, 01-02-2010). Such networks can help overcome some of the wind industry's main barriers to entry e.g. obtaining capital, identifying procurement relations and hiring personnel.

Furthermore attending industry conferences, joining industry networks and keeping updated with market information is obviously crucial and is a good way to identify business opportunities, the turbine manufacturers have further expressed the importance of their suppliers having a profound understanding of the industry. The strong US wind industry networks, especially AWEA, but also regional ones, pose great opportunities within this area. There are also special supply chain events organized by AWEA with the purpose to promote strong supplier and customer relationships. Further, according to project developer Nathan (24-11-2009) the US wind industry is still quite small and personal relationships are important, especially since large scale wind farm investment requires a certain amount of personal trust. , such relationships can be made at AWEA events. Participating at wind industry events may help actors overcome barriers to entry related to getting recognition and initiating relationships with the large OEMs, hiring people with the right competencies as well as creating demand for new products and services.

Though Swedish technology has strong legitimacy in the US one must not underestimate the value of being able to display it in a full scale concept in the home market. A proven technology is not only easier to sell, but also creates less technology risks when entering a new market, further having access to such track records removes one of the major barriers to entry. In the case of the US wind industry strong competitive advantages may lie in being able to show that the technology is adapted to the US specific wind conditions and thus will require less maintenance. To adapt to US conditions one way may be to collaborate with US universities like SBI did with Kettering University. However the seemingly poor collaboration between academia and the wind industry in the US may pose difficulties and one way to overcome such problems is to utilize university collaborations in the home market and through that network identify, and get into contact with, potential academic collaborators in the US. Another way, like SBI did, is to go through regional economic development centers likely to have connections with universities within their region.

The general recommendations for company's wanting to enter a new country also apply to the US wind energy industry. Since personal relationships seem to be of high importance within the US wind industry having an American CEO, like SBI, or someone with much experience in the country, who knows the culture well is very valuable. However due to the global characteristics of the industry, and the strong European base, the CEO also needs international experience.

Finally, important to consider when entering the US wind energy industry are the uncertainties regarding future policy development. It all comes down to the belief in growth potential versus the risks associated with a potential failure of the implementation of effective federal climate legislations.

However findings in this report support the belief of a positive industry outlook and that the inducement mechanisms are stronger than the blocking ones.

8 Conclusion

The purpose of this report has been to; investigate through an Innovation System (IS) perspective what inducement and blocking mechanisms are influencing the US wind energy industry, and from those mechanisms identify opportunities for Swedish component and service suppliers to enter the market.

Some important characteristics of the US wind energy industry that have been found during this research are the following;

- *Projects sizes and turbine sizes are large and growing bigger*
- *Wind resources are in some regions extremely strong with capacity factors up to 40%*
- *The installed capacity and the general support for wind installations varies much between states with Texas as by far the leading region*
- *The US industry is young but with experienced global actors*
- *The turbine market is fairly consolidated but there is an influx of new actors throughout the whole supply chain*
- *The technology was developed in Europe and has not yet been fully adapted to US specific wind conditions which may partly explain the high failure rates of key components*
- *A lacking domestic supply chain makes the industry dependent on import and led to large shortages of supply during the last couple of years contributing to a higher price of turbines*

Further the US wind energy industry has boomed since around the year 2007 and today the country is world leading in terms of installed capacity. Earlier the growth had mainly due to policy uncertainties been unstable with years of fairly large installations and years with no new installations at all. Due to a uneven market development a mobilization of complementary resources such as transmission lines, human capital and a domestic supply chain never took place. The recent strong growth of 2007-2009 seems to have changed that picture somewhat and as the globally large turbine manufactures now increasingly decide to locate manufacturing facilities in the country their strong belief in growth potential is signaled to the global industry attracting new actors. The same is true for large global project developers, mainly European, who are increasingly present in the US, these strong customers provides the industry with an articulated demand on large scale, cost efficient projects and turbines. Although things are improving important issues are still clouding the development, especially the lack of sufficient transmission lines and the political uncertainties regarding the enactment of a federal climate bill. Further the low price of natural gas is posing strong competition to wind.

The IS was analyzed through a functional analysis according to the Bergek et al (2008) scheme of analysis. Concurrently the Industry Life Cycle (ILC) was assessed. The US industry was late to enter the global ILC and thus have characteristics coming from both the early stage and the mature stages of an ILC. The industry is in the growth phase which according to theory is characterized with an increasing rigidity to change however the increasing number of new entrants implies that there is still room for incremental product and process innovation. In the early stage of the US wind industry’s ILC the most influential functions were Influence on direction of search, Market formation and increasing political and technical Legitimacy. Moving forward Legitimacy continues to be a strong driver and the focus on quality/cost is essential for improving technical legitimacy in the US. However Entrepreneurial experimentation and Resource mobilization are increasingly important to support a future industry development.

The inducement and blocking mechanisms identified as the outcome of the functional analysis were clustered together in order to highlight the strengths and weaknesses of the industry's future development. The four prominent areas of strength are; (1) the strong belief in growth potential articulated by leading customers, (2) increased investment in the supply chain showing a more stabilized industry development, (3) strong industry networks and (4) an increasing political and public focus on renewable energy. Together these create positive feedback loops that drive the industry forward and enable future growth. The three areas of weaknesses that, in turn create negative feedback loops hindering the industry growth and threatening the future development include the; (1) historical and present political uncertainty, the (2) lack of extensive knowledge base and industry know-how and ultimately (3) the lack of complimentary assets, especially transmission.

Based on these clusters of inducement and blocking mechanisms opportunities were identified for Swedish component and service suppliers; For component supply the major opportunities are drawn from the articulated need of a domestic supply chain, and therefore include most kinds of components especially key components and heavy components that are difficult to ship. However, due to barriers to entry e.g. increasing requirements on technology and need for a track record proving quality, for companies new to the field most opportunities seems to lie within manufacturing of less complex components or as a 2nd or 3rd tier supplier. The second kind of opportunities lies within services and does also include ad-on products related to service such as safety equipment, optimization of maintenance, site assessment tools etc. As of today it is mainly the OEMs who perform service and maintenance since most turbines are still under the warranty period. However as that period ends and as turbines get older the demand for O&M services is expected to increase. It is an increasing number of actors who wish to enter the field but as the current aftermarket has not yet been fully crystallized there are potential first mover's advantages within this field. Other services such as safety, crane services and construction services also pose opportunities in the US. The third opportunity for component suppliers lies within the supply of electrical components. These include both electrical infrastructure components and additional electrical components within the turbine that are increasingly required in order to meet higher compliance demands from gird operators.

There are great opportunities within the US win energy industry, although the window of opportunity does not last forever and the time to go there is now and during the coming 3-4 years. Though great opportunities, especially small actors face challenging barriers to entry. A case study of Swedish Biogas International, a Swedish clean tech company who established a subsidiary in the US was performed in the research. The key success factors of that study were compared to the characteristics of the US wind energy industry in order to see if the same factors could be utilized in the wind energy industry;

- *Swedish companies should look for formal collaborations between US and Sweden since they may imply support by state governors which was important for SBI.*

- *The use of networks to identify, for example customers, suppliers, business opportunities and research collaborations, are important which is why the American Wind Energy Association (AWEA) is very valuable.*

- *Having a proven technology with track record is important though adapting that technology to US specific conditions is also in almost all cases necessary.*
- *To be able to utilize networks and to understand the US culture having a native CEO or someone who has spent much time in the country is very valuable.*

9 Discussion

During the research some differences in opinion regarding what is actually driving the demand for new installation of wind power have been identified. On the one hand there are those who believe that policy, i.e. tax credits and RPS, is the one and only main driver for wind development and other factors cannot be considered as direct market forces. On the other hand there are those who believe that the price of the generated electricity is the main driver for new installations and that policy is only an indirect market force that works through lowering the price of electricity. This report takes an innovation system approach and has thus instead of looking at market drivers investigated the mechanisms that are inducing the market growth and therefore consider these two perspectives as complementary views rather than contradictive. There are obviously several influencing forces and it is this report's belief that all of the different, direct and indirect, forces of the innovation system need to be in place in order for the market to continue optimal growth. For example, looking at the state of Texas which partly due to a high price of natural gas prior to the economic downturn saw new installations far exceeding the state's RPS target. However with the recent decreased price of natural gas new installations are increasingly dependent on tax credits and a renewal of the RPS as well as a build out of new transmission lines. Findings in this report support the belief of a positive industry outlook for the US wind energy industry. Further the inducement mechanisms are considered to be stronger than the blocking ones and through positive feedback loops they will manage to grow even stronger.

As a second research question this report aims at identifying opportunities for Swedish component and service suppliers to enter the market. As mentioned in the analysis; suppliers already involved with the wind industry in Europe will, obviously, have a strong advantage moving to the US. There are important barriers to entry that need to be considered and since Sweden has, compared to Denmark and Germany, failed at creating a domestic wind energy industry these barriers pose even larger challenges for new Swedish actors who wish to enter the US market (Johnson & Jacobsson, 2003). With the global characteristics of the wind industry a majority of these barriers to entry are applicable to most wind energy markets and therefore must be dealt with largely independent of geographical location. Swedish actors cannot afford to miss out on the huge global potential that the industry poses and must therefore find ways to overcome the challenges. Although with challenging hinders the opportunities on the US market are large and the right time to move there is now and during the coming 3-4 years. An interesting topic for future research is therefore to investigate strategies to overcome such barriers for companies originating from a country, such as Sweden, with a less developed wind industry

Finally this report aimed at using the innovation system scheme of analysis by Bergek et al (2008) as a tool for identifying business opportunities within the US wind energy industry. The strength of this approach has been the broad coverage and understanding of the industry that it has provided, however the weakness is the lack of a detailed focused study of the potential business opportunities.

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Appendix 3

Generic Questionnaire to actors involved within the US wind energy industry

Company Info

1. Explain your business model, what is it you provide as a wind energy developer?
    a. What services?
    b. Where in the supply chain are you?
    c. Who are your customers?
2. For how long time have you been involved in the wind energy industry in USA?
    a. Prior to the wind energy industry have you been involved in any other industry.

Market Development

3. What is your view on market development?
    a. Demand: which customer segments are increasing the most, e.g.:
        i. Small
        ii. Community
        iii. Utility
    b. What is driving demand e.g. ?:
        i. Access to policy incentives
        ii. Energy prices
        iii. State policies, e.g. RES?
        iv. End customers
    c. General attitude towards wind energy?
    d. What are the major obstacles for further development?
    e. Future view on market development?

Supply Chain relations

4. Which actors do you work with? (please name the 5 most important if possible for each category)
    a. Park owners
    b. Component suppliers
    c. Service suppliers
    d. Turbine manufacturers
    e. Power purchasers
5. What specific demands do the different actors pose?
    a. Quality, price, service, certificates etc.?
    b. How would you describe their bargaining power?
6. How did you first get in contact with these actors, had you worked with them before on the U.S. or European market?
7. Do the relationships differ between these actors in anyway?
8. How is the competition between developers e.g.?:
    a. Many small companies?
    b. Name your main competitors in the region?
    c. What factors do you compete on e.g. price, quality, time, reputation, access to logistics
9. What would you characterize the main obstacles in the production e.g.?:
    a. Uncertainty in orders, varying demand
    b. Failing spare parts
    c. Transmission problems hindering expansion
    d. Access to cranes and other tools or competencies

10. What are your major specific concerns in the supply chain?
    a. Lead time etc.?
    b. How do you deal with coordinating the construction logistics?
    c. Collaborations between the different kinds of suppliers concerning logistics to remote places e.g. constructing the foundation, delivering the blades, importing components from Europe.
    d. How could the coordination efforts be improved?
    e. How much time could be saved?
11. Do have different experiences when it comes to different sizes of projects?
12. Are you at the moment trying to find new solutions for a specific technical problem?
    a. Cooperating with any universities/ national labs?
13. Are you involved in the permitting process?
    a. How would you describe the process
    b. What are the major obstacles in receiving the permit?
        i. e.g. Landowners, appeal, bureaucracy

Service & Maintenance

14. Do you as a owner provide the parks with maintenance, post the 2 year guarantee from the manufacturing
15. What experiences have you had with maintenance e.g.?:
    a. How often?
    b. Coordination of maintenance?
    c. Costs?
16. What are the current customer trends when it comes to maintenance?
17. How involved are the big turbine manufacturers in service?

Policy

18. Have you received any grants, tax rebates etc from the ARRA?
19. Are you or your customers dependent on policy incentives?
20. How would you rate your state’s efforts to promote renewable energy?
    a. Have you seen any significant differences the last couple of years
    b. What are the current trends in your state when it comes to wind energy?
21. What industry organizations or local networks are you member of?