Wind Technology

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Localization in Domestic Wind Industry Development

Different Models for Wind Power Technology Localization

There are many policy mechanisms that can be used to promote the utilization of wind power, but wind power utilization does not necessarily lead to or require the development of a local wind technology manufacturing industry (Mitchell, 1995; Johnson and Jacobsson, 2003; Connor, 2004), or the *localization* of wind turbine manufacturing (the term *localization* as used throughout this paper refers primarily to the act of domestic manufacturing). Instead, wind power technology is often imported from abroad until a large enough domestic demand for wind power has been established to support local manufacturing.

Even if localization of wind technology manufacturing is achieved, either for components or for entire wind systems, such localization can take multiple forms. Leading foreign wind turbine manufacturers may simply decide to establish a local manufacturing presence in which certain components or entire turbines are manufactured in the local market. On the other end of the spectrum, wind technology may be developed entirely locally, through local innovation or research and development initiated by a domestic firm itself, or in combination with other domestic research organizations. An intermediate strategy is for wind turbine technology to be acquired by a local firm through the transfer of that technology from overseas firms that have already developed advanced wind turbine technology, often through a licensing agreement. In some cases, after acquiring wind turbine technology through a technology transfer arrangement, a firm will then further innovate based on the transferred design and create a new design.

A technology transfer typically includes the transfer of the technology design as well as the transfer of the property rights necessary to reproduce the technology in a particular domestic context. A common form of property right included in a technology transfer is a patent license: a legal agreement granting permission to make or use a patented article for a limited period or in limited territory (Columbia, 2003). A technology transfer may or may not include technological know-how associated with the development of the technology itself, despite the fact that the physical transfer of technology alone is likely insufficient to ensure the transfer of the technological knowledge that recipient companies would need to produce comparable wind technology domestically, and to ensure its continued operation and maintenance in the field. Cases have shown that the transfer of technology without supplemental “know-how”—also referred to as the “software” needed to accompany the “hardware”—may detract from the lasting effectiveness of the technology transfer (IPCC, 2000). For example, a purchase of a license to produce one model of wind turbine will likely be less valuable than an arrangement that also includes on-site training of the workers in the purchasing company by the transferring company.

A local wind industry may aspire to manufacture complete wind turbine systems, to manufacture certain components and import others, or perhaps just to serve as an assembly base for wind turbine components imported from abroad. These different models for local manufacturing are contrasted in Table 1.

Each of these basic approaches to and forms of localization implies different degrees of local manufacturing and technology ownership, and each may require a distinct and targeted set of policy measures. Countries may also move from one model to another over time as local technological capabilities expand.

Table 1. Models for the Localization of Wind Power Technology Manufacturing

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	Imported	Localized
Turbine Assembly	Foreign turbine components	Know-how associated with turbine assembly
Component Manufacturing	All components not manufactured locally	Select components (e.g., towers, blades, generator, gearbox)
Full Turbine Manufacturing	Nothing, except perhaps a few select components	Virtually the complete wind turbine system

Potential Benefits of Localization

The potential benefits of local wind turbine manufacturing generally include: 1) economic development opportunities through sales of new products, job creation, and increased local tax base; 2) opportunities for the export of domestically-made wind turbines to international markets, further enhancing the prospects for local economic development; and 3) cost savings that result in lower-cost wind turbine equipment, a lower cost of wind-generated electricity, and therefore higher growth rates in domestic wind capacity additions. Another less tangible benefit to wind technology localization, but clearly a motivating factor for several countries, is a desire for national achievement in what is viewed as an emerging industry.

The development of any new industry, including wind power, can create new domestic job opportunities, and wind development is often credited with creating more jobs per dollar invested and per kilowatt-hour generated than fossil fuel power generation (see, e.g., Singh and Fehrs, 2001). Direct jobs are typically created in three areas: manufacturing of wind power equipment, constructing and installing the wind projects, and operating and maintaining the projects over their lifetime.

Many countries and sub-national governments aspire to create a locally-owned, domestic wind turbine manufacturing industry with the goal of eventually exporting their turbines overseas and tapping into the expanding global market for wind energy. Denmark's Vestas, the largest turbine supplier in the world, sold over 99% of its turbines outside of Denmark in 2004. India's Suzlon exported 13% of its turbines in 2003 and sold none abroad in 2004, but aspires to increase this percentage and is currently setting up manufacturing companies and subsidiaries in several other countries (Suzlon, 2005; BTM, 2005). These export opportunities promise to bring further economic benefits to the host country of the manufacturer.

Local manufacturing of wind turbines or wind turbine components can also potentially reduce costs through a reduction in labor costs, a reduction in raw materials costs, and/or a reduction in transportation costs. Countries with lower wage rates such as India and China expect to be able to realize cost savings through domestic manufacturing of wind turbines compared to their European and American counterparts. This cost reduction is potentially significant for those turbine components that are particularly labor-intensive, including rotor blade manufacturing (Allen Consulting Group, 2003; Krohn, 1998).

Cost savings from in-country production could also be realized if a country is dependent on importing foreign turbines from overseas and shipping costs are high. The tower, a particularly large, heavy component that is less technically sophisticated than other components, is often the first component to be manufactured in a local market. The Canadian Wind Energy Association estimated that transport costs for wind turbines, composed of both overseas shipping costs and on-land freight transport, represent 5-10% of the entire system cost for imported turbines, and 3-5% for domestically made turbines (CanWEA, 2003).

The extent to which these various benefits are realized will be affected by the approach to and form of localization that is achieved. For example, localization in the form of foreign firms developing local manufacturing facilities may provide increased local employment and tax revenues, but much of the know-how, intellectual property, and profit may still remain in the hands of foreign firms, with little or no technology transfer or in-country local innovation necessarily taking place. Even if local workers are used in the manufacturing process, they could be subject to strict non-disclosure agreements, complicating the transfer of their acquired expertise to local industries.

Consequently, it is important for governments hoping to promote local manufacturing within a region to be very clear about not only which of the models in Table 1 to pursue and over what timeframe, but also about whether the goals of creating this industry are to create jobs and a demand for raw materials, or to also facilitate the transfer of advanced wind power technology to develop domestically owned wind turbine manufacturing companies. Policy incentives may need to be designed and targeted differently depending on the specific goals for localization.

Barriers to Local Wind Industry Development

Though there are many potential benefits to local wind manufacturing, there are also significant barriers to entry into what has become a relatively mature industry, particularly as turbine size has grown larger and the technology has become more complex. Many companies have decades of experience in wind turbine research and development, and the leading turbine manufacturers are becoming larger and encompassing more global market share through mergers and acquisitions. Over three quarters of global wind turbine sales come from only four turbine manufacturing companies: Vestas, GE Wind, Enercon and Gamesa (BTM, 2005). These companies have either spent years building strong global reputations, or have benefited through strategic mergers and buyouts. Players in the industry are becoming increasingly larger as demonstrated by General Electric's entrance in 2002 and, more recently, Siemens' entry in October 2004 through its purchase of Danish company Bonus. The wind industry is in the process of consolidation; Danish wind companies Vestas and NEG Micon had the highest and second highest global market shares respectively at the time of their merger at the end of 2003, and the two largest Spanish turbine manufacturers, Gamesa and Made, also merged at the end of 2003. Wind companies with the financial backing of mega-corporations like GE and Siemens can provide quality assurance to customers, both through their reputation and their ability to offer multi-year service warranties that dramatically reduce investment risk. New entrants will need to compete with these large, well-known companies.

Limited indigenous technical capacity and wind industry experience can also make quality control a serious challenge for companies just entering the wind sector, either as complete turbine or components suppliers. National standards requiring the use of advanced technology can shut out emerging firms that are likely to initially develop less-advanced technology. In addition, there are limited global locales possessing a skilled labor force in wind power, with Denmark still representing a unique hub of skilled laborers and an experienced network of key components suppliers to support turbine manufacturers. Suzlon recently decided to base its international headquarters in Denmark to take advantage of this knowledge base, even though it has stated that it is unlikely to sell its turbines to the Danish market (WPM, October 2004:25). Technological innovation in the wind industry is currently being pushed by the desire to develop larger onshore and offshore wind turbine technology, reduce costs, increase efficiency, and improve grid interactions. These continuous advancements create a barrier to new entrants that may struggle to catch up to the best available technology. Some technologically advanced countries have been able to enter the wind market at a late stage without much prior experience in wind turbine manufacturing due to their relatively developed technical knowledge base. Countries with less indigenous technical capacity will have a harder time attempting to develop new technologies, particularly wind turbine technology where experience in other industries has been shown to result in spillovers that can be an asset in wind technology development (Kamp et al., 2004). Additionally, intellectual property rights have served as barriers to entry in several markets.

One way that local firms attempt to overcome some of these barriers is by establishing partnerships in the form of joint venture enterprises with more advanced foreign wind power manufacturers. In many international joint-venture arrangements, the foreign transferor forms a partnership with the domestic transferee in order to receive preferential treatment within a desired domestic market that it might otherwise not have had access to, and in return will often transfer its technology at a lower cost than it would have if it did not have an interest in the company’s future earnings. In general, the acquisition of foreign technology is most important for technically sophisticated wind components or systems where prior experience is highly valuable. An example of such an arrangement was the joint venture, Gamesa Eolica, formed between the Spanish turbine manufacturer Gamesa (holding a 60% share) and the Danish manufacturer Vestas (holding a 40% share). Gamesa paid licensing fees to Vestas that allowed it to manufacture turbines made with Vestas technology solely within the Spanish market (Wustenhagen, 2003).

Although the acquisition of technology from overseas companies is one of the easiest ways for a new wind company to quickly obtain advanced international technology and begin manufacturing turbines, there is a major disincentive for leading wind turbine manufacturers to license proprietary information to companies that could become competitors. An example of this outcome has been realized by Vestas, which licensed its turbine technology to Gamesa, and now competes with it for sales in the global market; Vestas' experience may now prevent similar arrangements with leading wind turbine manufacturers from being replicated throughout the world. This is particularly true for technology transfers from developed to developing countries, where a similar technology potentially could be manufactured in a developing country setting with less expensive labor and materials, and result in an identical but cheaper turbine. The result is that new developing country manufacturers often obtain technology from second or third tier international wind power companies that have less to lose in terms of international competition and more to gain in fees paid from the license.

A final barrier to localization is that the World Trade Organization (WTO) has established stringent trade regulations among member countries that prevent the use of trade barriers. The WTO Technical Barriers to Trade Agreement "tries to ensure that regulations, standards, testing and certification procedures do not create unnecessary obstacles" to trade, and "discourages any methods that would give domestically produced goods an unfair advantage" (WTO, 2004). To this end, policies that tax the importation of wind turbines, or even policies that require the use of domestically produced turbines, could be construed as "protectionist" and barriers to trade. The legality of protectionist policies to differentially support local industries like wind turbine manufacturing remains in question, but WTO rules may restrict a country's ability to use certain policy instruments to encourage local manufacturing.

Each of these barriers makes it more challenging for new firms to enter the wind manufacturing sector. These barriers also suggest that many countries may initially be more successful in localizing component manufacturing and assembly functions, or in attracting foreign wind manufacturers to establish local manufacturing facilities. Developing new, locally owned, successful full-service wind turbine manufacturers may need to be a longer-term goal in some emerging markets.

The Role of Domestic Markets in Supporting Wind Power Technology Manufacturers

Regardless of the motivations, benefits, and barriers to local wind turbine manufacturing, countries hoping to play a leading role in the wind manufacturing industry will likely have to develop a stable and sizable domestic market for wind power utilization. Most leading wind turbine manufacturers are from countries with significant domestic wind power development, and most have been very successful in their home markets, as illustrated in Table 2.

Table 2. Largest Wind Markets and Domestic Wind Companies

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	Cumulative Wind Capacity (End of 2004, MW)	**Leading Domestic Wind Companies** (Global rank in 2004)	**Percent of Installed Turbines Made by a Domestic Company** (2004)[3]
Germany	16,649	Enercon (#3), REpower (#7), Nordex (#10), Fuhrlander (#13)	54%
Spain	8,263	Gamesa (#2), Ecotecnia (#9); EHN/Ingetur (#11)	73%
US	6,750	GE Wind (#4)	49%
Denmark	3,083	Vestas (#1), Bonus/Siemens (#5)	99%
India	3,000	Suzlon (#6); NEPC (#14)	51%
Italy	1,261	None	0%
Netherlands	1,081	None	0%
Japan	991	Mitsubishi (#8)	32%
UK	889	DeWind (#12 in 2003; no sales in 2004)	0%
China	769	Goldwind (#15)	21%
Canada	444	None	0%
Australia	421	None	0%
Brazil	30	None	0%
WORLD	47,912		

For example, in 2003, Denmark's leading wind turbine manufacturers Vestas and Bonus (now Siemens) comprised 99% of home market share. Given the declining size of the Danish wind market, the saturation of home market sales has led these companies to expand into overseas markets. In wind markets that have experienced more recent growth, there are also several examples of domestic wind companies selling to their home market in their early years and expanding abroad as they gain experience. In the year 2004, for example, Spanish manufacturers were very successful at home with 73% of domestic market share, and despite being relatively new entrants were already expanding overseas with 23% of global market share. Also in 2004, Indian companies had 51% of market share at home and were just beginning to expand abroad from a 4% global market share, while Chinese manufacturers are doing well at home with a 21% market share, but had yet to expand internationally.

The Importance of the Home Market

Since most wind power companies are de facto global companies, the country in which they are based is arguably becoming less and less relevant. However, it is in the early years of a wind company's development when the home market is likely to make up the majority of that company's market share; more mature wind power companies tend to export a larger share of their wind turbines, especially once they have saturated the domestic market.

The Importance of Sizable, Stable Demand

In addition to aggregate domestic market size, many studies note the importance of sizeable, stable *annual* demand for wind turbines as a factor in the decision to shift or commence a local manufacturing venture in a particular location (Connor, 2004; Johnson and Jacobsson, 2003). One study estimates that a minimum steady demand of 150-200 MW per year for three or more years is crucial to developing a nascent local wind technology manufacturing industry, while a more capable and aggressive local industry is likely to require a minimum of 500 MW each year (CanWEA, 2003).

The top five countries in terms of total installed wind capacity at the end of 2004 were Germany, Spain, USA, Denmark, and India (Table 2); wind turbine manufacturers from these top five countries sold 94% of all wind turbines installed globally in 2004. Figure 2 provides a closer examination of annual capacity installations over the ten-year period from 1995 through 2004 for these five countries. Germany clearly stands out as having maintained the most sizable and stable market. Over 400 MW of new capacity were installed each year for the ten-year period starting in 1995. From 1999 to 2004, Germany installed over 1500 MW per year. Spain achieved over 200 MW of annual capacity additions from 1997 through 2004, and from 2001-2004 installed over 1000 MW of capacity each year. Denmark's market has also been relatively stable, especially during its major growth period in the late 1990s, though its aggregate market size is now smaller than that of other leading countries and it has destabilized somewhat in recent years.

The US and Indian markets have been much less stable than those of Germany, Spain and Denmark. Annual installations in the US were highest in 2001 and 2003 with over 1600 MW installed each year. However, annual installations dipped well below 200 MW per year between 1995 and 1998, and again in 2000. The year 2004 was also slow in the US, as the on-again, off- again nature of the federal production tax credit has created significant uncertainty in the market in recent years. India's market has also been unstable, with initial growth in the mid 1990s, a slowdown in the late 1990s, and some resurgence in recent years. From 2001 to 2004, however, India has been able to maintain annual installations of over 200 MW per year. Though the instability of the Indian and US markets has not stopped local investments in wind manufacturing (in part because the long-term market potential is so large in both countries), it has often complicated the process of developing successful local wind manufacturing industries. Vestas, for example, has long considered investing in local manufacturing in the US, but has put those plans on instability.

Summary

The information provided above supports the claim that wind turbine manufacturers usually get their start in their home country markets; a trend that is clear in the largest markets of Denmark, Germany, Spain, the US, and India, as well as some of the smaller, emerging markets.

A stable and sizable home market can provide local manufacturers with the necessary testing ground to sort out their technology and manufacturing strategies and experiment with technology designs. Once greater technical maturity has been achieved within the local market, local companies can then transition to the global market, and focus on exports and establishing foreign subsidiaries.

A stable and sizable home market may also be a pre-requisite to luring leading foreign manufacturers to establish local manufacturing facilities or to develop local joint venture partnerships. A stable home market signals to both local manufacturers and to foreign firms that they have the long-term planning horizon necessary to allow them to reasonably invest in the market. Companies facing unstable or small markets, on the other hand, will be less willing to spend money on R&D, product development, and local manufacturing facilities.

International Experience with Policies to Support Wind Power Localization

Now that the relationship between market size and wind manufacturing success has been illustrated, we turn to an examination of the policies that have supported or are supporting local wind turbine manufacturers in the twelve countries that are the focus of our study: Denmark, Germany, Spain, the United States, the Netherlands, the United Kingdom, Australia, Canada, Japan, India, Brazil, and China.

Local wind technology manufacturing may be driven by policy support or by other factors, such as regional advantages that come from labor and technological expertise that can facilitate learning networks. While regional advantages such as learning networks have been shown by other researchers to have played a role in shaping wind industry development (Van Est, 1999; Kamp, 2002; Gipe, 1995), this paper focuses exclusively on the policy mechanisms that have been used to promote a local wind manufacturing industry. Policy measures are what national and sub-national governments have at their disposal to encourage wind manufacturing localization, and an identification of these measures may assist policymakers as they examine ways to encourage domestic manufacturing of wind turbines or components.

Policy measures to support wind industry development can be grouped into two categories: direct and indirect measures. Direct measures refer to policies that specifically target local wind manufacturing industry development, while indirect measures are policies that support wind power utilization in general and therefore indirectly create an environment suitable for a local wind manufacturing industry (by creating sizable, stable markets for wind power). The discussion that follows covers both of these types of measures, and is a summary of the more detailed country case studies provided in Lewis and Wiser (2005).

Direct Support Mechanisms

Policies that directly support local wind turbine or components manufacturers can be crucial in countries where barriers to entry are high and competition with international leaders is difficult. A variety of policy options exist to directly support local wind power technology manufacturing, and several policy options have proven effective, as demonstrated in a number of countries (Table 4). These various policy mechanisms do not all target the same goal; some provide blanket support for both international and domestic companies to manufacture locally, while others provide differential support to domestically-owned wind turbine or components manufacturers. Most countries have employed a mix of the following policy tools.

Local Content Requirements The most direct way to promote the development of a local wind manufacturing industry

is by requiring the use of locally manufactured technology in domestic wind turbine projects. A common form of this policy mandates a certain percentage of local content for wind turbine systems installed in some or all projects within a country. Such policies force wind companies interested in selling to a domestic market to look for ways to shift their manufacturing base to that country or to outsource components used in their turbines to domestic companies. Unless the mandate is specifically targeted to domestically owned companies, it will have the blanket effect of encouraging local manufacturing regardless of company nationality.

Local content requirements are currently being used in the wind markets of Spain, Canada, Brazil and China. Spanish government agencies have long mandated the incorporation of local content in wind turbines installed on Spanish soil; the creation of Gamesa in 1995 can be traced in part to these policies. Even today, local content requirements are still being demanded by several of Spain's autonomous regional governments that "see local wealth in the wind"—in Navarra alone, it is estimated that its 700 MW of wind power has created 4000 jobs (WPM, October 2004:45). Other regions, including Castile and Leon, Galicia and Valencia, insist on local assembly and manufacture of turbines and components before granting development concessions (WPM, October 2004:6). The Spanish government has clearly played a pro-active role in kick- starting a domestic wind industry, and the success of Gamesa and other manufacturers is very likely related to these policies.

At least one provincial government in Canada—Quebec—is pursuing aggressive local content requirements in conjunction with wind farms developed in its region. In May 2003, Hydro-Quebec issued a call for tenders for 1000 MW of wind for delivery between 2006 and 2012 which included a local content requirement; this 1000 MW call was twice the size initially planned by the utility, but it was doubled by the Quebec government with the hope of contributing to the economic revival of the Gaspe Peninsula (WPM, May 2003:35; WPM, April 2004:41). The government also insisted that Quebec's wind power development support the creation of a true provincial industry that included local manufacturing and job creation by requiring that 40% of the total cost of the first 200 MW be spent in the region—a proportion that rises to 50% for the next 100 MW and 60% for the remaining 700 MW (WPM, May 2003:35; April 2004:41). In addition, the government stipulated that the turbine nacelles be assembled in the region, and that project developers include in their project bidding documents a statement from a turbine manufacturer guaranteeing that it will set up assembly facilities in the region (WPM, May 2003:35). GE was selected to provide the turbines for a total of 990 MW of proposed projects upon its agreement to meet a 60% local content requirement, and is currently establishing three manufacturing facilities in Canada (WPM, June 2005:36). In October 2005, another call for tenders was released, this time for 2000 MW to be installed between 2009-2013. This call requires that 30% of the cost of the equipment must be spent in the Gaspe region and 60% of the entire project costs must be spent within Quebec Province (Hydro-Quebec, 2005).

The Brazilian government has also pursued policies governing wind farm development that include stringent local content requirements, primarily through the recent Proinfa legislation (the Incentive Program for Alternative Electric Generation Sources) that offers fixed-price electricity purchase contracts to selected wind projects. Starting in January 2005, the Proinfa legislation requires 60% of the total cost of wind plant goods and services to be sourced in Brazil; only companies that can prove their ability to meet these targets can take part in the project selection process. In addition, from 2007 onwards, this percentage increases to 90% (Cavaliero and DaSilva, 2005).

China has also been using local content requirements in a variety of policy forms. China's 1997 "Ride the Wind Program" established two Sino-foreign joint venture enterprises to domestically manufacture wind turbines; the turbines manufactured by these enterprises under technology transfer arrangements started with a 20 percent local content requirement and a goal of an increase to 80 percent as learning on the Chinese side progressed (Lew, 2000). China's recent large government wind tenders, referred to as wind concessions, have a local content requirement that has been increased to 70% from an initial 50% requirement when the concession program began in 2003. Local content is also required to obtain approval of most other wind projects in the country, with the requirement recently increased from 40% to 70%.

Local content requirements require a large market size in order to lure foreign firms to undertake the significant investments required in local manufacturing. If the market is not sufficiently sizable or stable, or if the local content requirements are too stringent, then the advantages of attracting local manufacturing may be offset by the higher cost of wind equipment that results. Some concerns of this nature have already been raised in Brazil, where only one wind turbine manufacturer appears currently able to meet the local content requirements. The potential negative impact of local content requirements on turbine costs has also been raised in Canada and

China. These experiences suggest that local content requirements can work, but should generally be applied in a gradual, staged fashion and only in markets with sufficient market potential.

Financial and Tax Incentives Preference for local content and local manufacturing can also be encouraged without being mandated through the use of both financial and tax incentives. Financial incentives may include awarding developers that select turbines made locally with low-interest loans for project financing, or providing financial subsidies to wind power generated with locally-made turbines. Tax incentives can be used to encourage local companies to get involved in the wind industry through, for example, tax credits or deductions for investments in wind power technology manufacturing or research and development. Alternatively, a reduction in sales, value-added-tax (VAT), or income tax for buyers or sellers of domestic wind turbine technology (or production) can increase the competitiveness of domestic manufacturers. In addition, a tax deduction could be permitted for labor costs within the local wind industry. Tax or financial incentives can also be applied to certain company types, such as joint ventures between foreign and local companies, in order to promote international cooperation and technology transfer in the wind industry, and to specifically encourage some local ownership of wind turbine manufacturing facilities.

Germany’s 100MW/250MW program provided a 10-year federal generation subsidy for projects that helped to raise the technical standard of German wind technology, and over two- thirds of the total project funding for this subsidy went to projects using German-built turbines (Johnson and Jacobsson, 2003). Regional support for German industrial efforts with a bias towards local wind manufacturers have been reported as well (Connor, 2004). A further German policy that may have preferentially supported German turbine technology was the large-scale provision of “soft” loans (loans that are available significantly below market rates) for German wind energy projects.

Canada has implemented a tax credit on wages paid out to local labor forces in an attempt to encourage large wind turbine manufacturers to shift jobs to Canada. To provide a further incentive for local manufacturing, a Quebec provincial government program also offers a 40% tax credit on labor costs to wind industries located in the region, and a tax exemption for the entire manufacturing sector through 2010 (WPM, June 2003:40). Spain’s production tax credit on windpowered electricity (supplemented by incentives offered in at least one province) is granted only to turbines that meet local content requirements (WPM, February 2001:20). In India, the excise duty is exempted for parts used in the manufacture of electric generators (Rajsekhar et al., 1999). Australia (at the national and provincial levels), China, and a number of US states have also employed a variety of different tax incentives to encourage localization of wind manufacturing.

China provides a reduced VAT on joint venture wind companies to encourage technology transfer (NREL, 2004). China has also used financial incentives to promote domestic wind industry development since its 1997 "Ride the Wind Program," which allocated new technology funds to two government-facilitated joint venture enterprises to domestically manufacture wind turbines. The Danish Government's Wind Turbine Guarantee also offered long-term financing of large projects using Danish-made turbines and guaranteed the loans for those projects, significantly reducing the risk involved in selecting Danish turbines for a wind plant.

Favorable Customs Duties Another way to create incentives for local manufacturing is through the manipulation of

customs duties to favor the import of turbine components over the import of entire turbines. This creates a favorable market for firms (regardless of ownership structure) trying to manufacture or assemble wind turbines domestically by allowing them to pay a lower customs duty to import components than companies that are importing full, foreign-manufactured turbines. Customs duties that support local turbine manufacturing by favoring the import of components over full turbines have been used in Denmark, Germany, Australia, India, and China (Rajsekhar et al., 1999; Liu et al., 2002). This type of policy may be challenged in the future, however, as it could be seen to create a trade barrier and therefore be illegal for WTO member countries to use against other member countries.

Export Credit Assistance Governments can support the expansion of domestic wind power industries operating in

overseas markets through export credit assistance, thereby providing differential support to locally-owned manufacturers. Though such assistance may also come under WTO's fire, export assistance can be in the form of low-interest loans or "tied-aid" given from the country where the turbine manufacturer is based to countries purchasing technology from that country. Export credit assistance or development aid loans tied to the use of domestic wind power technology have been used by many countries, but most extensively by Germany and Denmark, encouraging the dissemination of Danish and German technology, particularly in the developing world. For example, the Danish International Development Agency (DANIDA) has offered direct grants and project development loans to qualified importing countries for use of Danish turbines.

Quality Certification A fundamental way to promote the quality and credibility of an emerging wind power

company’s turbines is through participation in a certification and testing program that meets international standards. There are currently several international standards for wind turbines in use, the most common being the Danish approval system and ISO 9000 certification. Standards help to build consumer confidence in an otherwise unfamiliar product, help with differentiation between superior and inferior products and, if internationally recognizable, are often vital to success in a global market. Denmark was the first country to promote aggressive quality certification and standardization programs in wind turbine technology and is still a world leader in this field; quality certification and standardization programs have since been used in Denmark, Germany, Japan, India, the USA, and elsewhere, and are under development in China. They were particularly valuable to Denmark in the early era of industry development when they essentially mandated the use of Danish-manufactured turbines, since stringent regulations on turbines that could be installed in Denmark made it very difficult for outside manufacturers to enter the market.

Research and Development (R&D) Many studies have shown that sustained public research support for wind turbines can be crucial to the success of a domestic wind industry, and such efforts can and typically do differentially support locally owned companies. R&D has often been found to be most effective when there is some degree of coordination between private wind companies and public institutions like national laboratories and universities (Sawin, 2001; Kamp, 2002). For wind turbine technology, demonstration and commercialization programs in particular can play a crucial role in testing the performance and reliability of new domestic wind technology before those turbines go into commercial production.

R&D funding has been allocated to wind turbine technology development by every country mentioned in this paper, with the success of R&D programs for wind technology seemingly more related to how the funding was directed than the total quantity of funding. Although the US has put more money into wind power R&D than any other country, for example, an early emphasis on multi-megawatt turbines and funding directed into the aerospace industry are thought (in retrospect) to have rendered US funding less effective in the early years of industry development than the Danish program (the same has been said about early German and Dutch R&D programs). Denmark's R&D budget, although smaller in magnitude than some other countries, is thought to have been allocated more effectively among smaller wind companies developing varied sizes and designs of turbines in the initial years of industry development (Sawin, 2001; Kamp, 2002).

Indirect Support Mechanisms

Earlier we demonstrated that success in a domestic market may be an essential foundation for success in the international marketplace, and that fundamental to growing a domestic wind manufacturing industry is a stable and sizable domestic market for wind power. Achieving a sizable, stable local market requires aggressive implementation of wind power support policies. The policies discussed below aim to create a demand for wind power at the domestic level.

Feed-in Tariffs Feed-in tariffs, or fixed prices for wind power set to encourage development (Lauber, 2004; Rowlands, 2005; Sijm, 2002; Cerveny and Resch, 1998), have historically offered the most successful foundation for domestic wind manufacturing, as they can most directly provide a stable and profitable market in which to develop wind projects. The level of tariff and its design characteristics vary among countries. If well designed, including a long term reach and sufficient profit margin, feed-in tariffs have been shown to be extremely valuable in creating a signal of future market stability to wind farm investors and firms looking to invest in long-term wind technology innovation (Sawin, 2001; Hvelplund, 2001). As discussed earlier, Germany, Denmark and Spain have been the most successful countries at creating sizable, stable markets for wind power; all three of these countries also have a history of stable and profitable feed-in tariff policies to promote wind power development. The early US wind industry was also supported by a feed-in tariff in the state of California, though this policy was not stable for a lengthy period. Among the twelve countries emphasized in this paper, the Netherlands, Japan, Brazil, and some of the Indian and Chinese provinces have also experimented with feed-in tariffs, with varying levels of success.7

Mandatory Renewable Energy Targets Mandatory renewable energy targets (also called renewables portfolio standards, mandatory market shares, or purchase obligations) are a relatively new policy mechanism being put to use in several countries. In its most common design, this policy requires that a fixed percentage of electricity in each retail suppliers' portfolio be generated by renewable resources, though policy design can be tailored to specific domestic markets. These policies have been implemented as Renewables Portfolio Standards (RPS) in twenty-one US States (Wiser et al., 2005), as a national Mandatory Renewable Energy Target (MRET) in Australia (Australian Greenhouse Office, 2004), as a Renewables Obligation (RO) in the UK (Mitchell et al., 2006), and as the Special Measures Law in Japan (Nishio and Asano, 2003). Similar policies are also beginning to be developed in several Canadian provinces.[8] Since nearly all of these programs have only been implemented recently, their impact on wind power development has so far been relatively modest; wind power development in the US has been tied in part to the implementation of state Renewables Portfolio Standards, however, and the market for wind in the UK is also beginning to expand (Van der Linden et al., 2005; Langniss and Wiser, 2003; Bird et al., 2005). Concerns have also been raised about the competitive mechanisms created by these policies, as well as the possible long-term political uncertainty that can surround the targets and their design, which may create market uncertainty and lower overall industry profitability, thereby fostering an environment that offers less incentive for wind localization (Finon and Menanteau, 2003; Mitchell et al., 2004; Menanteau et al., 2003). A determination of how common this problem is must await further experience with the policy mechanism.

Government Tendering Another way for the government to facilitate wind development is to run competitive

auctions for wind projects or resource tenders for prime wind sites, accompanied by benefits like long-term power purchase agreements. However, government tendering programs of this type have historically not provided long-term market stability or profitability, due in part to the often uncertain or long lead times between tenders and the fierce competition among project developers to win the competitive process. The UK's Non-Fossil Fuel Obligation, which provided periodic tenders for renewable energy generation during the 1990s, is the most commonly cited example of government-run bidding processes. Ultimately, policymakers found that these tenders were not sufficiently certain and the contracts not sufficiently profitable to draw much manufacturing interest to the country (Mitchell, 1995). In addition to the UK, among the twelve countries emphasized here, government-run competitive bidding for wind projects has been or is being used in Canada, India, Japan, some US states, and China. The programs in Canada and China have resulted in significant new wind capacity under contract in the past couple of years. Whether these countries experience similar problems to those experienced in the UK—which in part were a result of poor policy design—remains to be seen.

Financial and Tax Incentives Financial incentives of various forms, whether based on electrical production or capital

investment and whether paid as a direct cash incentive or as a favorable loan program, can also be used to encourage renewable energy development. Without a long-term power purchase agreement, however, this policy mechanism has been found to generally play a supplemental role to other policies in encouraging stable and sizable growth in renewable energy markets. Virtually all of the countries included in this survey have used financial incentives of various types to encourage wind development.

Many governments also provide a variety of tax-related incentives to promote investment in or production of renewable power generation. These incentives can come in the form of capital- or production-based income tax deductions or credits, accelerated depreciation, property tax incentives, sales or excise tax reductions, and VAT reductions.

One of the most successful tax incentives in terms of contributing to installed capacity is the US's Production Tax Credit (PTC). Though the PTC has certainly been effective at promoting wind installations, its on-again, off-again nature has resulted in a very unstable market for wind farm investment, as was illustrated in Figure 2. In the 1990s, India's market was also driven in large part by various tax incentives, including 100% depreciation of wind equipment in the first year of project installation, as well as a 5-year tax holiday (Rajsekhar et al., 1999). China has VAT reductions and income tax exemptions on electricity from wind, and a number of other countries have also used or continue to use a variety of tax-based incentives.

As with financial incentives, tax-based incentives are generally found to play a supplemental role to other policies, and countries that have relied heavily on tax-based strategies (e.g., US and India) have often been left with unstable markets for wind power.

Wind power.

The 20% Wind Scenario offers substantial positive environmental impacts in today's carbon-

constrained world. Wind plant siting and approval processes can accommodate increased rates of installation while addressing environmental risks and concerns of local stakeholders.

Wind energy is one of the cleanest and most environmentally neutral energy sources in the world today. Compared to conventional fossil fuel energy sources, wind energy generation does not degrade the quality of our air and water and can make important contributions to reducing climate-change effects and meeting national energy security goals. In addition, it avoids environmental effects from the mining, drilling, and hazardous waste storage associated with using fossil fuels. Wind energy offers many ecosystem benefits, especially as compared to other forms of electricity production. Wind energy production can also, however, negatively affect wildlife habitat and individual species, and measures to mitigate prospective impacts may be required. As with all responsible industrial development, wind power facilities need to adhere to high standards for environmental protection.

Wind energy generally enjoys broad public support, but siting wind plants can raise concerns in local communities. Successful project developers typically work closely with communities to address these concerns and avoid or reduce risks to the extent possible. Not all issues can be fully resolved, and not every prospective site is appropriate for development, but engaging with local leaders and the public is imperative. Various agencies and stakeholders must also be involved in reviewing and approving projects. If demand increases and annual installations of wind energy approach 10 gigawatts (GW) and more, the wind energy industry and various government agencies would need to scale up their permitting and review capabilities.

To date, hundreds of wind projects have been successfully permitted and sited. Although the wind energy industry must continue to address significant environmental and siting challenges, there is growing market acceptance of wind energy. If challenges are resolved and institutions are adaptive, a 20% Wind Scenario in the United States could be feasible by 2030. As noted by the Intergovernmental Panel on Climate Change (IPCC), under certain conditions, renewable energy could contribute 30% to 35% of the world's electricity supply by 2030 (IPCC 2007).

This chapter reviews environmental concerns associated with siting wind power facilities, public perceptions about the industry, regulatory frameworks, and potential approaches to addressing remaining challenges.

Site-Specific & Cumulative Concerns

About 10% to 25% of proposed wind energy projects are not built—or are significantly delayed—because of environmental concerns. Although public support for wind energy is generally strong, this attitude does not always translate into early support for local projects. Site-specific concerns often create tension surrounding new energy facilities of any kind. Although most wind energy installations around the United States pose only minor risks to the local ecology or communities, some uncertainties remain. Further research and knowledge development will enable some of these uncertainties to be mitigated and make risks more manageable.

Local stakeholders generally want to know how wind turbines might affect their view of their surroundings and their property values. In addition, they might be concerned about the impact on birds and other wildlife. Weighing these risks and benefits raises questions about the best management approaches and strategies.

Wind energy developments usually require permits or approvals from various authorities, such as a county board of supervisors, a public service commission, or another political body (described in more detail in Section 5.5). These entities request information from a project developer—usually in the form of environmental impact studies before construction—to understand potential costs and benefits. The results of these studies guide jurisdictional decisions. A single lead agency might consider the entire life-cycle effects of a wind energy project. This is in contrast to fossil fuel and nuclear projects, in which the life-cycle impacts (e.g., acid rain and nuclear wastes) would be widely dispersed geographically. No single agency considers all impacts.

For many government agency officials, the central issue is whether wind energy projects pose risks to the resources or environments they are required to protect. Officials want to know the net cumulative environmental impact (i.e., emissions reductions versus wildlife impacts) of using 20% wind power in the United States, whether positive or negative. Uncertainty can arise from inadequate data, modeling limitations, incomplete scientific understanding of basic processes, and changing societal or management contexts. Complex societal decisions about risk typically involve some level of uncertainty, however, and very few developers make decisions with complete information (Stern and Fineberg 1996). Because a great deal of experience exists to inform decision making in such circumstances, residual uncertainties about environmental risks need not unduly hinder wind energy project development.

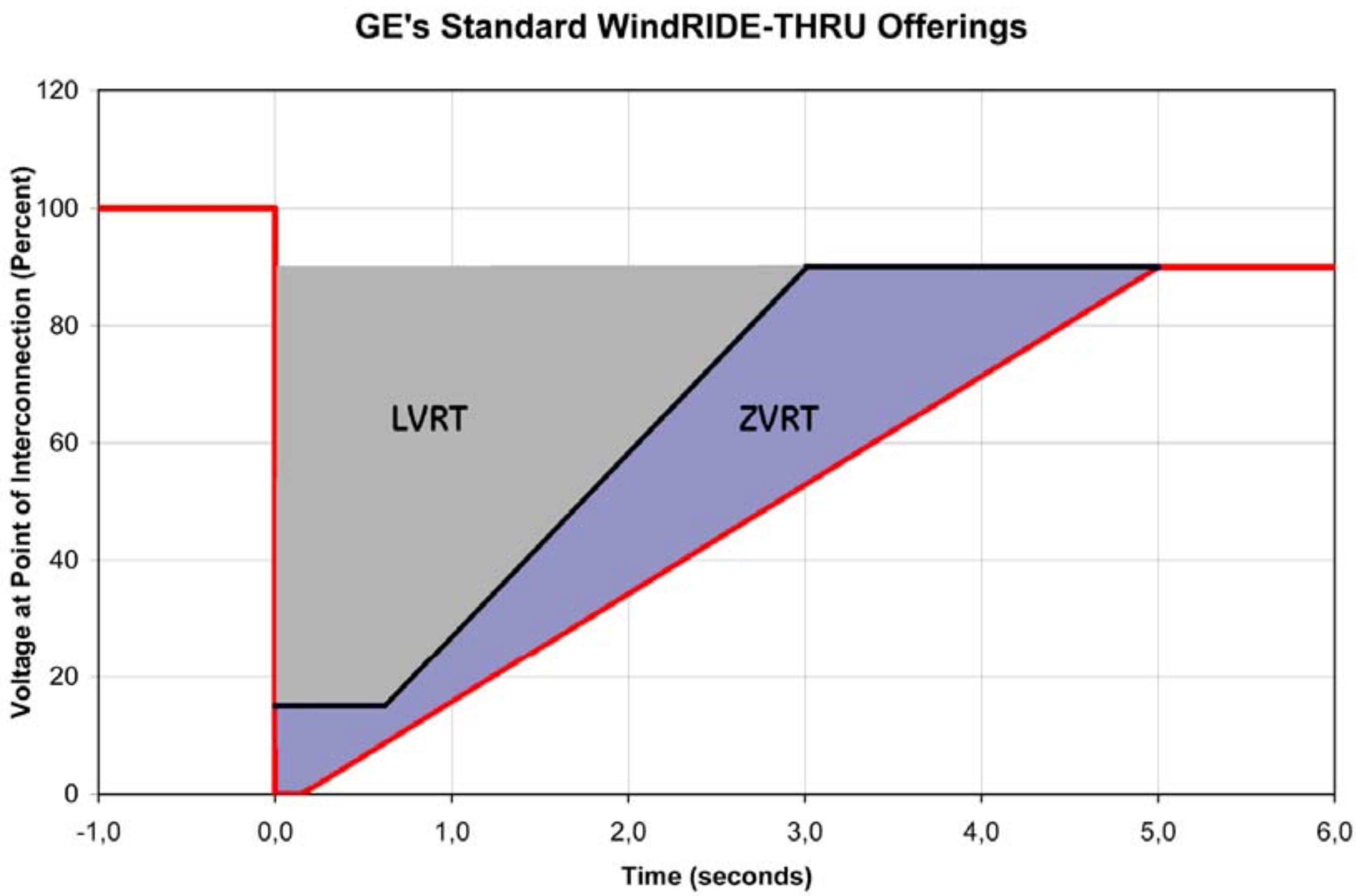
The wind industry may encounter difficulties entering a competitive energy marketplace if it is subject to requirements that competing energy technologies do not face. Risks associated with wind power facilities are relatively low because few of the significant upstream and downstream life-cycle effects that typically characterize other energy generation technologies are realized. Moreover, the potential risks are not commensurate when comparing wind energy and other sources (such as nuclear and fossil fuels), and comparative impact analyses are not readily available. These analyses would need to examine the broader context of the potential adverse effects of wind power on human health and safety (minimal), ecology, visibility, and aesthetics in relation to the alternatives.

The acceptability of risks will vary among communities and sites, so it is important to understand these differences and build broad public engagement. Developing effective approaches to gaining the public's acceptance of risks is a necessary first step toward siting wind energy facilities.

PMSG-turbine Technology.

GE offers a variable speed PMSG-turbine with planetary gear and a full power converter. The turbine can basically be operated at any speed, since its pitch regulation and nominal generator output are the only limiting factors. This type of turbine is relatively new and represents GE Winds latest development to meet higher demands from grid operators and is available with the additional feature; LVRT/ZVRT (Low voltage ride-through/Zero voltage ride through).

Rotor diameter: 100 m Rated wind speed: 13.5 m/s Power rating: 2.5 MW Terminal voltage: 690 V



SWOT Analysis

Strength:

GE being a global leader in many divisions of its business, wind turbines has added more value to the strong portfolio it already have. GE has been one of the leading in wind turbines as well since 2002. Having a strong manufacturing base, very loyal customers, good reputation, international market experience and skill with its previous ventures, cutting edge technologies and global supply chain GE is one of the biggest wind turbine manufacturer.

Weakness:

Though GE have managed to keep a steady course, but there have been many remarkable weakness as well. Some of the weakness of GE has come from the very strength of its own other divisions and the company’s main focuses on continue becoming a global powerhouse giant. Having strong competitors only focused on the wind energy sector like Vestas with control over 40% of the market in offshore wind farm markets, facing an increased cost in construction and raw material providers unstable economy, most importantly the reliance and main decision makers of social and political society support.

Opportunities:

There are several opportunities, which might help ensure GE's future revenues and advantages. One of the opportunities is to expand into emerging markets like Asia by providing offshore wind turbine farms with competitive cost and quality over its competitors, since electric and gas energy is expensive, there will be an increased demand for alternative energy like wind turbines. Being green now a days have been one of the main important societal need this days, demand for healthy environment is one of the contributing factor to the many opportunities.

Treats:

Some of the primary treats for GE is economic downturns, the very expensive cost for technology development, many existing and emerging competitors. There are technological uncertainties with the high demand of society of alternative wind energy, more treats also comes from change in preference or growth in demand of a different type of energy in the future, the decrease in another types of energy cost and natural disasters are some of the treats of the GE turbines.

SWOT	**Strengths** • strong manufacturing base • good reputation • international market experience & skills • cutting edge technologies • global supply chain	**Weaknesses** • Strong competitors • Reliance on social & Political support • Increased cost in construction
Opportunities • Emerging markets (Asia) • Increased demand for	• Expand into foreign markets by taking advantage of the Strong manufacturing plants	• use the increased demand to increase the market share in emerging markets • provide a reasonable price for customers to chose wind energy over electric

alternative energy • Demand for healthy environment • Increase in electric cost		energy
Treats • Economic downturns • Technology development cost • Emerging competitors • Technological uncertainty • Different type of alternative energy demand growth • Decrease in energy cost • Natural disasters	• more R&D in emerging technologies	• work with the competitors • focus on other divisions alternative energy manufacturing • sell the wind turbine energy division

Wind Power Technology and General Market Trends.

Wind Energy Market: Globally wind energy market has seen consistent demand for the last ten years despite the current crisis, there has been record number of installations of the turbines in 2010, and the growth rate for the industry for the last five years is at an average of 27.4%.
Despite the economic crisis, the large growth rate has been achieved largely due to a 50% reduction in the installation rates in the US, the world's second largest wind market, but the rise of Chinese turbine manufacturers should also be noted as 47% of the installations were in the country itself.

Depending on the efficiency measures implemented, by 2030 world energy needs are predicted to be between 30 and 60% higher than current levels. The IEA estimates that around 4,500 GW of new energy capacity needs to be installed before 2030, requiring investments of more than US$ 13 trillion.
This sharp increase in world energy demand will require significant investment in new power generating capacity and grid infrastructure, especially in emerging economies such as India and China.

It is interesting to note that in the year 2011 that 43.9 GW installations are expected, with 18.3 GW installations to be completed by the first half of 2011. Globally around 215 GW was added by June 2011.

The top five wind markets have recorded a consistent growth and account for the largest group of turbine manufacturers are China, USA, Spain, India, and Germany accounting for 73% of the global wind capacity.

Economic considerations

Top executives at General Electric Co. have grown more optimistic about the prospects for the company's long-struggling business of selling natural-gas turbines, thanks in part to the need to replace power generated by Japan's hobbled nuclear fleet and the possibility demand for nuclear plants could fall in the wake of that country's crisis.

The view, expressed during a call to discuss GE's earnings, shows how the company could ultimately get a financial boost from Japan's nuclear crisis even as it comes under fire for its role in designing and building reactors at the heart of events there.

Chief Executive Jeff Immelt listed a handful of factors that could spur sales of gas turbines, among them the need to provide new sources of power supply in Japan and the possibility nuclear plants will fall out of favor as new capacity is added longer term.

"The dynamics have really changed subsequent to the disaster and tragedy in Japan," Chief Financial Officer Keith Sherin said on the call. "You see people canceling their plans to continue development of new nuclear plants."

Gas turbines are a key component of GE's big energy business, but sales slumped when the recession cut into power demand. Profit at GE's Energy Infrastructure unit fell 7% to $1.38 billion in the first quarter from a year earlier, the only decline among GE's main segments.

GE now sees the unit returning to growth in the second half of the year. U.S. sales remain weak—GE said it had only one turbine order in the U.S. in the first quarter; but Messrs. Immelt and Sherin said they see stronger demand in the Middle East, Japan and elsewhere. Factors contributing to demand also include growth in emerging markets, lower natural-gas prices and environmental rules, Mr. Immelt said.

GE also has ambitions for its solar-energy business. This month, the company announced plans to build the biggest photovoltaic-panel factory in the U.S., aiming to have its solar-energy unit eventually match the scope of its $6 billion wind-turbine unit.

The plant, which will open in 2013, will produce thin-film solar panels that will generate 400 megawatts of electricity annually, or enough to power 80,000 homes a year. The company said it will have invested $600 million in solar technology and commercialization by the time the new factory opens.

GE has been beefing up its Energy Infrastructure unit with acquisitions over the past year. The unit contributed $9.45 billion of the company's $38.4 billion in revenue in the first quarter.

Installed Wind Turbine Market Shares 2010

THE TABLE CONTAINS PRELIMINARY DATA, LAST UPDATE: 04/19/2011

Manufacturer	**2010 Share 2010, % (according to BTMConsult, installed capacity 2010: 39.4GW)** (5)	**Share 2010, % (according to MAKE)** (1)	Share 2009, % (according to BTMConsult, installed capacity 2009: 38.1GW)(4)
Vestas (DK)	**14.8**	**12**	12.5
Sinovel (CN)	**11.1**	**11**	9.2
GE Energy (US)	**9.6**	**10**	12.4
Goldwind (CN)	**9.5**	**10**	7.2
Enercon (GE)	**7.2**	7	8.5
Suzlon (IN)	**6.9**	**6**	6,4
Dongfang, DEC (CN)	**6.7**	7	6.5
Gamesa (ES)	**6.6**	7	6.7
Siemens (GE)	**5.9**	**5**	5.9
Guodian United Power (CN)	**4.2**	**4**	n/a
MingYang WindPower (CN)	n/a	**3**	n/a
REpower (GE)	n/a	**2**	3.4
Nordex (GE)	n/a	**2**	n/a
Sewind (CN)	n/a	**2**	n/a
XEMC (CN)	n/a	**1**	n/a
Mitsubishi (JP)	n/a	n/a	n/a
Acciona (ES)	n/a	n/a	n/a
Clipper (US/UK)	n/a	n/a	n/a
Alstom Ecotecnica (ES)	n/a	n/a	n/a

Fuhrländer (GE)	n/a	n/a	n/a
Windey (CN)	n/a	n/a	n/a
WindFlow (NZ)	n/a	n/a	n/a
WindWinD (FIN)	n/a	n/a	n/a
DeWind (DSME, KOREA)	n/a	n/a	n/a
Areva Multibrid (GE)	n/a	n/a	n/a

Conclusions

Different short- and long-term goals for localization—including whether to encourage local or foreign ownership of domestic manufacturing facilities, and whether to localize assembly, components, or entire turbines—will affect the benefits of localization and should influence the policy tools used to encourage that localization. Consequently, for countries seeking to encourage local wind technology manufacturing, we believe that a first step should be a comprehensive assessment of the potential economic, employment, and cost reduction benefits associated with different forms of local wind turbine manufacturing, as well as a detailed assessment of existing domestic capabilities in the wind sector. A review of WTO rules and the constraints they impose on support mechanisms would also be valuable. Canada and Australia, for example, recently commissioned studies to determine their competitive advantages in wind turbine manufacturing. Such assessments may provide critical input to government policymakers who must decide which localization strategies to pursue, and over what timeframe

Once the localization strategy is clear, a set of policy tools to implement that strategy must be selected. As shown in this paper, a country can maximize its attractiveness for local manufacturing by establishing a combination of direct and indirect policies to support wind industry development. Direct support for local manufacturing—through local content requirements, financial and tax incentives, favorable customs duties, export credit assistance, quality certification, and research, development, and demonstration—has proven particularly beneficial in countries trying to compete with dominant industry players.

Selection of an appropriate set of direct policy incentives hinges on the fundamental goals of localization. For example, if the development of domestically owned manufacturers is the goal (not just the localization of manufacturing from international turbine vendors), then localization requirements or incentives might specifically target domestically owned manufacturers rather than providing blanket incentives to all forms of localization. Export credit assistance, and research, development, and *especially* demonstration programs, can also be targeted to truly domestic companies. If instead localization of any ownership type is the goal, then standard local content requirements or incentives, along with favorable customs duties, might be sufficient. The design details of localization requirements, R&D programs and other policies should also vary depending on whether assembly, component, or turbine localization is the goal.

Since localization goals are likely to change over time, policy incentives can be adapted accordingly; for example, a country may start with a goal of attracting foreign turbine manufacturers, then attempt to initiate local component manufacturing, and eventually develop its own turbine manufacturer. A gradual, staged approach is suggested to ensure that policy goals and local content requirements match local industry capabilities, and do not unnecessarily raise the cost of wind power in the local market.

Regardless of which of these direct incentives are used, a sizable local market appears to be a pre-requisite to achieving successful localization. Spain, for example, has recently enticed numerous foreign companies to manufacture locally, but this is likely due not only to stringent local content requirements but also to the market stability that Spain's feed-in tariff provides. Quebec has also recently been able to attract local manufacturing, again partly due to stringent local content requirements and labor tax incentives, and partly due to an extremely large project tender that has established a sizable market. In fact, as shown in this paper, virtually all of the leading wind turbine manufacturers come from countries that have historically maintained strong policy environments for wind development.

A stable feed-in tariff has clearly proven to be one of the most successful mechanisms to date for promoting large-scale wind energy markets that offer the stability necessary to attract local manufacturing . However, several policies may be effective if implemented carefully, including a mandatory market share or RPS, or government-run project auctions or concessions. Regardless of the policy mechanism, it seems clear that whether new wind turbine manufacturing entrants are able to succeed will depend in large part on the utilization of their turbines in their own domestic market, which in turn will be influenced by the annual size and stability of that market.

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