# The German Wind Technology Cluster

## Microeconomics of Competitiveness

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# 1. Country Analysis

**1.1 National Economic Performance:** Germany is a federal republic with 16 states, situated in the center of Europe. With a population of 82 million people and a size of 357,000km2, its 6,000km border includes a coastline of 2,400km. Following the cold war and after a peaceful revolution in Eastern Germany, the country was reunified in 1990. More than twenty years on, stark regional imbalances still persist, with western states in general more prosperous than their eastern neighbors.

Germany is a key player in the European Union and considered its economic engine with the highest gross domestic product among all members, totaling US$3.6 trillion in 2008 (World Bank, World Development Indicators, 2009). Germany's GDP per capita of around US$33,500 (in PPP), ranks it slightly above the European Union average.

Given its membership of the European Union and its structure as a federal state, political decision-making in Germany is spread through several levels: European institutions prescribe approximately 50% of Germans laws, the European Central Bank sets the monetary policy and the European Commission and the European Parliament define the rules on trade, common market, environment, agriculture and increasingly so on domestic security. The European Court is accessible to every citizen and its rulings are binding on all member States. The federal government has its main competencies in the areas of tax and economic policy, foreign policy and then energy policy, labor market and social welfare, while the state level in Germany is exclusively responsible for education, including universities.

***A Story of Real Wages and Productivity:*** For most of the 1990s Germany saw strong and stable growth in its GDP per capita averaging 2-3% per year. Following a severe crisis during the 2002-2003 recession several reforms were introduced in the labor market and growth started to pick up again, reaching 3% in 2006.

To understand Germany's competitiveness and economic success over the past decades, it is impossible to ignore productivity. Since 1990 Germany has been able to grow labor

productivity steadily every year at an average of 2%. Until 2003 most gains obtained with increasing productivity were transferred to workers through increases in real wages, which followed this growth trend. In 2003, the federal government introduced a set of ambitious reforms under the "Agenda 2010" motif. These reforms aimed at liberalizing the up to then inflexible labor market that made hiring and firing decisions extremely difficult. Unemployment benefits and subsidies were also shortened and restricted. Since the turn of the century Germany has been able to keep real wage growth under tight control, particularly when compared with some of its main competitors such as the UK, France and the United States, all of which saw labor unit costs increase by more than 15% over the last two decades.

Following these reforms, wages in Germany saw an accentuated decline in real terms while productivity kept increasing. This allowed German firms, in particular those oriented towards exports, to become comparatively increasingly competitive in the international scene, funneling productivity gains to consumers through comparatively lower prices / higher quality products as opposed to workers through real wage increases.

***An export oriented economy:*** Germany is world renown for its exports. For decades it ranked as the largest exporting country in the world, being only surpassed by China in 2009.

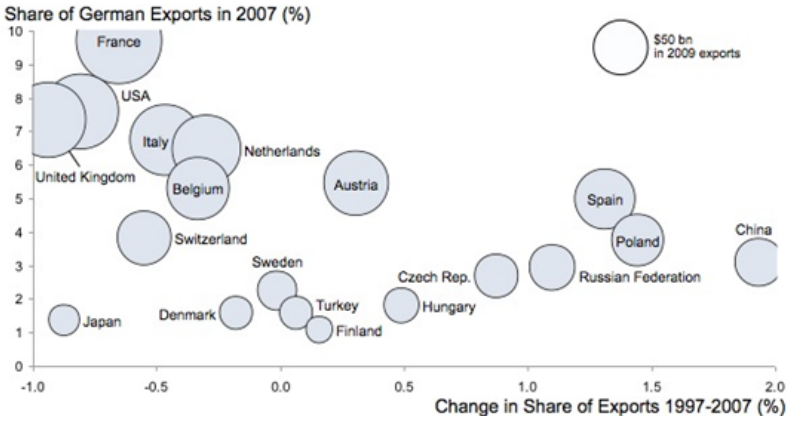
Germany has several large and developed clusters with more than 10% of worldwide export market-share, in areas as diversified as automobiles, production technology, biopharmaceuticals, heavy machinery, metal mining and manufacturing, analytical instruments, transportation and logistics and business services. As shown in Exhibit 4, most have increased their share of worldwide exports significantly over the past ten years.

The importance of exports in Germany's economy has increased substantially over the past decades, representing in 2009 41% of GDP compared with 25% in 1991. Driven in large part by tighter integration with European Union members and the introduction of the Single European

Market, export volumes have increased steadily every year and more than doubled when the 1991-2009 period is considered.

Surprisingly, Germany has been able to continue growing export volumes and market share while suffering acute exchange rate appreciation - since 2000 the euro has appreciated more than 36% against the US dollar. This has been possible thanks to the real wage / productivity trends discussed above but also by the fact that Germany has strategically reoriented its export markets towards emerging economies, with several Eastern European countries, China and Russia playing a larger role in absorbing German exports while the importance of traditional large trade partners such as France, the UK and the United States has decreased (**Figure A**).

**Figure A - German Export Markets**




Source: Prof. Michael E. Porter, International Cluster Competitiveness Project, Institute for Strategy and Competitiveness, Harvard Business School; Richard Bryden, Project Director. Underlying data drawn from the UN Commodity Trade Statistics Database and the IMF BOP statistics.

### 1.2 National Competitiveness: Country Diamond

***Factor conditions:*** Germany has excellent infrastructure. It is well connected by road and rail to its European neighbors. High-speed rail links are offered to France, Belgium, the Netherlands, Austria and Switzerland. With open access to the rail infrastructure the competition between the state owned dominating railway company and private competitor's gains momentum. Germany has well developed water ways and ports as well as airports. Frankfurt Airport with 51 million passengers in the last 12 months (Airports Council International, April 15, 2010) is the third largest European airport after London Heathrow and Paris Charles de Gaulle.

In addition to Germany's excellent scientific infrastructure within universities and numerous research centers, the country has a unique apprenticeship education system that has tried to be widely copied throughout the world. The system consists of two main components: a dual track system that ensures most students who don't pursue higher education are directed towards professional training at an early age to acquire a specific skill set; and a close link between companies and schools in defining curricula. This allows companies to have lower training costs and students to have higher productivity once they start working. Additionally it provides a large output of skilled labor and creates longer-term employment with reduced incentives for churn.

Skilled labor is readily available but in general the labor market remains rigid despite reforms in recent years (Agenda 2010). A major concern is unemployment, which is only slowly being reduced. Participation in the work force is also lower than in countries like the United States, Japan or the United Kingdom. Combined with the demographic effect of an ageing society the improvement of the labor force is key to competitiveness. Therefore the retirement age has been increased from 65 to 67 years.

Germany is one of the most innovative Countries in the world. With 109 U.S. patents per million inhabitants in 2008 Germany is ranked number three in the European Union. The gap to the United States (255 patents) and Japan (264) remains remarkable. The patent system within the European Union remains a problem: the European patent is more expansive than the U.S. patent and it has to be translated in all European languages.

Weaknesses in factor conditions are the availability of venture capital and the low inward FDI. Although the business environment has improved, e.g. by reduction of start-up days required for a new business from 24 to 18 days, there is still a huge gap to the U.S. with just 6 days (IMD Lausanne, World Competitiveness Yearbook 2010).

***Context for Firm Strategy and Rivalry:*** Germany is part of the common European market, which is the biggest economy worldwide with a 2008 GDP of more than US$ 18 trillion

(International Monetary Fund, World Economic Outlook Database, April 2009). The high diversification of the economy in both the domestic German and the common European markets provides a hugely competitive business environment for German companies.

The high efficiency of large companies and SME by international standards is the most important factor for the economic success of Germany. These companies are hugely competitive and follow global strategies by off shoring and outsourcing. Throughout the last five years German SMEs became even more competitive than large companies and performed better than US companies (IMD Lausanne, World Competitiveness Yearbook 2010). Many of these small enterprises are world market leaders but are little known to the public. There are three criteria for these so called "hidden champions": number one to three on the world market based on market share, a revenue of less than 5 billion US $ and a low level of public awareness (Simon, Hermann, Hidden Champions of the 21st Century). Examples of these hidden champions are Flexi, the producer of the rollable dog leash, and Wanzl, who produces two million trolleys a year. Also in the high tech sector SMEs are successful on the global market, for example Kavo Dental, a supplier for dentistry articles (Manager Magazin, Hidden Champions: Weltmarktführer aus Deutschland).

The latter example shows that these companies are also highly innovative and benefit from the excellent European intellectual property protection. In fact a unique aspect of Germany is the composition of its industrial fabric. As opposed to other large European economies that rely heavily on large state-owned industrial champions (e.g. France), Germany's industrial fabric is composed by thousands of "Mittelstand", small and medium enterprises that employ approximately one thousand people each. These companies compete fiercely with each other, focusing relentlessly on innovation and improving efficiency. With more than 80% of their production exported abroad, they are at the core of Germany's export success.

Finally, corporate governance in Germany is unique in the western world, with workers having a seat in company's boards and the right to influence decision-making. The non-

adversarial relationship between workers and employers brings enormous advantages, particularly during recessions. Instead of entering time consuming and value destroying disputes that clash employers against workers, decisions on how best to face the current challenges are made though "Job Alliances". These may introduce flexible working hours or pay reductions for example with the objective of keeping the company competitive in international markets while maintaining jobs. The federal government provides ample support to this system by subsidizing companies that retain surplus workers during recessions, which helps keep unemployment benefits and training costs low.

***Demand conditions:*** Germany has very sophisticated customers, in both the domestic and in the common European market. Both safety standards and environmental standards are very high. For example CO2 reduction targets are legally binding and strict environmental impact assessments are enforced at the European and national level.

In general the regulatory standards in Germany are very high. Technical standards have a long history: the German Institute for Standardization (Deutsches Institut für Normung DIN) was founded in 1917 and set thousands of industrial norms that are also used globally. One example is DIN A4, the paper size introduced in 1922. Very important is the role of the European Union by setting standards and therefore creating equal conditions in the common European market. This affects big industrial sectors in Germany, for example the chemical industry, car manufacturers and food production

The role of the government on the demand side is also important: German government expenditure per capita of US$ 8,000 is measurably higher than in the U.S. with US$ 7,000 (IMD Lausanne, World Competitiveness Yearbook 2010). The 2004 public expenditure quota in Germany (and in general in Europe) is with 47% much higher than in the United States with 37% or in Japan with 34% (Statistisches Bundesamt). This quota has never the less decreased in the last years and Germany has now a lower expenditure quota than many of its European competitors.

***Related and Supporting Industries:*** Germany has a very strong related and supporting industry, although this industry is very much concentrated in the south of Germany, namely in Bavaria and Baden-Württemberg. A broad variety and large number of local suppliers is supported by good availability of research and training services (universities, research centers). Further, easy access to the latest technology and a very highly developed machinery cluster provide excellent supply and generate high tech exports of 155 billion US $ in 2007 (IMD Lausanne, World Competitiveness Yearbook 2010). The machinery cluster and other clusters benefit from high skilled workers (Meister) and engineers and from a management culture that demands efficiency and precision.

**1.3 Major constraints to growth**

***Short-term constraints to growth:*** Despite the fact that Germany is one of the most competitive countries in the world, (ranked 8$^{th}$ in the 2009 Global Competitive Index), several issues present constraints to growth in the short term.

A high level of taxes, their distortionary effect and cumbersome regulations are still considered to undermine the competitiveness of German companies abroad. Despite recent reforms to the labor markets, rigidity of employment is still considered high in comparison to other countries (Germany ranks 89$^{th}$). Germany's dual-track education system, for long viewed as a major strength, is now gathering more and more critics who deem it outdated and not producing enough university-level graduates to fuel the knowledge economy. Quality of math and science education is comparatively low (41th) as well as tertiary enrollment (41$^{st}$).

Additionally German's comparatively underdeveloped venture capital system (63$^{rd}$) doesn't provide enough funding for entrepreneurial ventures, which stifles innovation.

Finally, with productivity decreasing for the first time in 2009 after two decades of uninterrupted growth and pressures for real wage increases mounting after nearly five years of declining purchasing power, there is increased concern that the foundation of German's successful export strategy might be at risk.

***Long-term constraints to growth:*** From a macro-economic point of view, Germany's over-reliance on exports as its growth engine makes it extremely susceptible to world recessions such as the one that happened in 2008/09 when exports fell by 15% in real terms and GDP contracted by 5%.

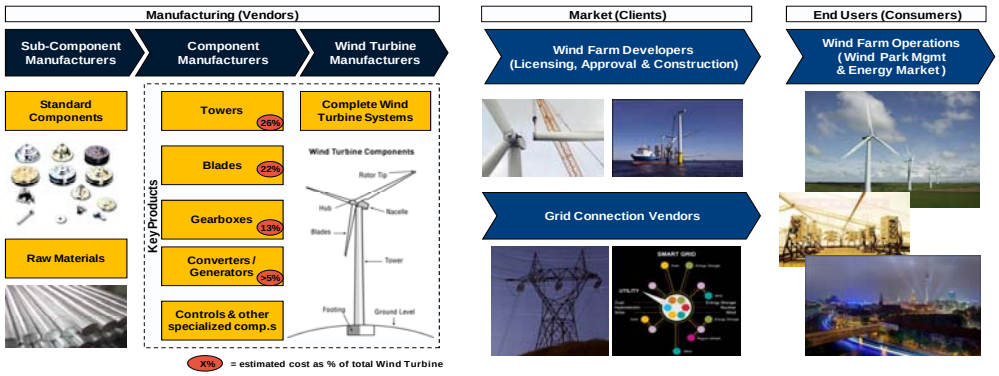
Additionally, while exports have quickly outpaced imports over the past two decades, generating current account surpluses that reached over 5% in 2009, domestic consumption as a % of GDP has remained for the most part flat and gross fixed capital formation has actually seen a severe decline. The fact that export surpluses, instead of being funneled towards domestic investment are being transferred abroad (a pattern that emerges when analyzing Germany's FDI flows) might pose economic problems in the long run if companies aren't making necessary investments in productive capacity.

Finally, from a demographic point of view, Germany's ageing population is expected to pose several economic constraints and social problems. In addition to the issue of lower workforce participation in the population, pension and health care costs are expected to see enormous increases in the next few decades, with some calculations pointing to the unfunded nature of these welfare system programs pushing implicit German debt levels to 250% of GDP (compared with a Debt/GDP ratio of 65% reported in 2007). This will eventually force Germany to impose higher taxes to fulfill the obligations of its welfare system if proper reforms aren't made.

## 2. Cluster Analysis

**2.1 The Global Wind Technology Industry:** Wind power technology has done remarkable leaps forward in the past 20 years, becoming an effective solution to the demand for renewable energy. The key orchestrators of the sector on the supply side are the Wind Turbine Manufacturers, as shown in **Figure C**. However, a very fast iteration of innovation cycles along the supply chain has been vital for the industry's success. The Wind Technology Supply Chain evolved through time to incorporate a large number of specialized actors that enable for healthy

competition within categories of suppliers, while fostering intense cooperation between the different types of actors, which complement each other and are often co-located in specific areas of the world. **Figure C : The Wind Technology Supply Chain.**




Source: Wind Directions (Jan-Feb 2007), miscellaneous company websites.

Access to relevant quantities of raw materials (especially steel and glass reinforced plastics), as well as to high precision mechanical and electronic sub-components, is a key prerequisite for the development of productive capacity in this space. Component manufacturers specialize in different parts of the turbine that require very different set of skills and levels of complexity[i]. Wind Turbine Manufacturers, which are often co-located with suppliers and hold most of the patents in the sector, provide a complete product that's ready to be installed into power generation plants. However, the role of Wind Park developers is key to allow for fast construction and development, and governments also play an important role in allowing a low wait time for permits, as well as in driving national market demand through the establishment of incentives (mostly feed-in tariffs or green certificates). Finally, Grid Connection vendors and providers of Smart Grid solutions also play an important role in allowing Wind Farms to be efficiently connected with the national power grid and to operate profitably. As a matter of facts, a wind turbine has a capacity factor that can vary between 30 and 80%, depending on what type of generator and how much of the generated power is actually transferred to the grid. Moreover, without appropriate storage capacity (e.g. using wind + hydro storage) it becomes impossible for wind to penetrate the market too much: the turbine generates power throughout the 24 hours but the grid needs more power during the day. Without storage capacity, peak electricity

produced at night would be wasted and the economics of the turbine using only the production during the day would not make it economically viable.

***Key Traits of Global Demand and Supply*:** Early demand in specific European countries has clearly enabled local manufacturers to take the lead in Wind Technology (**Figure D**). It is important to note how those markets are already reaching a certain level of internal saturation, while at the same time demand is strongly picking up in the US and Asia. Wind Power in 2008 accounted to approximately 20% of total electric power in Denmark, 11% in Spain and 6.6% in Germany (it was 18.5%, 7.9%, 5.1% respectively in 2005), versus 1.7% in India, 1.3% in the USA and 0.4% in China (EIA – US Energy Information Administration). As a result, the expected future growth is going to come from new geographies, as 34% of 2010 capacity additions are expected to be in Europe (compared to 87% in 2000), 33% in the Americas and 33% in Asia (Macquarie Research, August 2009).

**Figure D – Global Installed Capacity and key players by country of origin**

From a strategic point of view, it's important to note how early demand combined with compounded investments in R&D played a key role in making Wind Power commercially viable. From a technological and cost position point of view, the experience curve played a major role in opening up the technology (as per **figure E**), so that wind power is now one of the lower-cost technologies from a variable cost perspective. Including capital costs, wind remains comparable to other energy sources, as opposed to solar which is still a long way from reaching grid parity. Considering the high capital investment and the low variable costs, wind power appear to be a perfect substitute for nuclear, and as a matter of facts its penetration is much higher in the

countries that either banned or have an active policy of faseout, keeping nuclear to a minimum (Energy Watchgroup).

**Figure E – Cost of tower/annual kWh and Cost of energy generation**

**2.1. The German Wind Technology Industry:** Wind technology in Germany today spans almost 30 years of continuous growth and technological leadership. From the very beginning, the development of the wind technology cluster was closely supported by favorable economic policies that emanated from a wide ecological awareness in Germany in the 1980s. Paired with strong local demand for wind energy that was backed by governmental price guarantees and a tradition of both manufacturing and engineering capabilities a strong and tightly knit wind technology cluster emerged in the Northwest of Germany (German Wind Association, 2008).

Today this cluster hosts four of the worldwide top ten players by market share and is widely considered the innovation locus of the global wind industry. Germany in total holds 28% of worldwide market share in new installations. An export share of German production of 83% indicates that Germany has established itself as a competitive global player in the wind industry. With an installed capacity of 30 GW, second only to the United States on a national level, Germany has long experienced strong local demand that has strengthened the growth of the cluster. In 2008, the wind technology industry in Germany employed 90,000 people, the lion share of whom are located in the cluster in the Northwest. Industry leaders such as Enercon, Siemens, Nordex, and REPower continue to innovate and dominate the industry in terms of patents issued (Simon, 2009).

***Historical Development***: In the 1970s an ecological awareness unprecedented in other industrialized countries developed in Germany. Fueled by dying forests, polluted rivers, and acid rain a large segment of the German society got concerned with the state of the environment. This led to the founding of the Green party, which in the 1980s gained more traction and ultimately became an established player in the German political landscape (Bündnis '90/Die Grünen, 2010). Events such as the meltdown of the Chernobyl Nuclear plant in 1986 further stimulated fears within the population. As a result, policy makers turned towards renewable energies as a substitute for conventional energy generation through coal or nuclear power plants. This culminated in the passing of the energy feed-in law of 1991 that did not only guarantee all producers of renewable energy access to the distribution networks of the incumbent players, but also an attractive price guarantee for the power they generated. This spurred an investment boom in wind technology. Paired with decreasing production costs of wind energy and stable prices, this led to increasingly attractive returns for the investors. From the on-set policy makers had targeted the demand side instead of supporting the supply side, which proved to be an effective way to support the development of the renewable energy sector (German Wind Association, 2008).

In combination with a natural German appetite for innovative engineering solutions, this early demand fostered the emergence of several technological leaders that quickly agglomerated in a strong cluster in the Northwest of Germany. The Northwest, shaped by flat land, strong winds, and a natural proximity to the sea, provided an ideal breeding ground for the emergence of wind tower and turbine manufacturers, wind park operators as well as research institutions that could test the latest innovations in a formidable environment.

The emergence of the cluster also benefitted from Germany's long standing history in both power generation and turbine manufacturing. In both segments, Germany is endowed with strong clusters that command shares of worldwide exports of 12% and 11.5%, respectively. In either segment the share in German exports is growing at roughly 3% and therefore indicates a

further strengthening of Germany's position in this industry (Global Competitiveness Index Report, 2009). Related industries of this kind were able to provide necessary engineering skills of which some migrated towards the high growth wind technology sector.

In summary, the development of the wind technology cluster in Germany is the success story of favorable economic policies that induced strong early demand in the industry. Combined with technological leadership, several worldwide innovation leaders in wind technology quickly emerged. In what follows, the current status of the cluster if further explored by means of a concise cluster map that explains the roles of the different constituents of the cluster.

***Cluster Map*:** Germany's wind technology cluster is composed of a highly effective network of different constituents ranging from technology corporations that often are world market leaders in their space to governmental agencies that support the cooperation within the cluster. An illustration of the cluster map is provided in **Figure F**. The cluster is fairly concentrated with the majority of all German players in wind technology being located in just four states in the Northwest of Germany: Lower Saxony, Schleswig-Holstein, Bremen, and Hamburg.

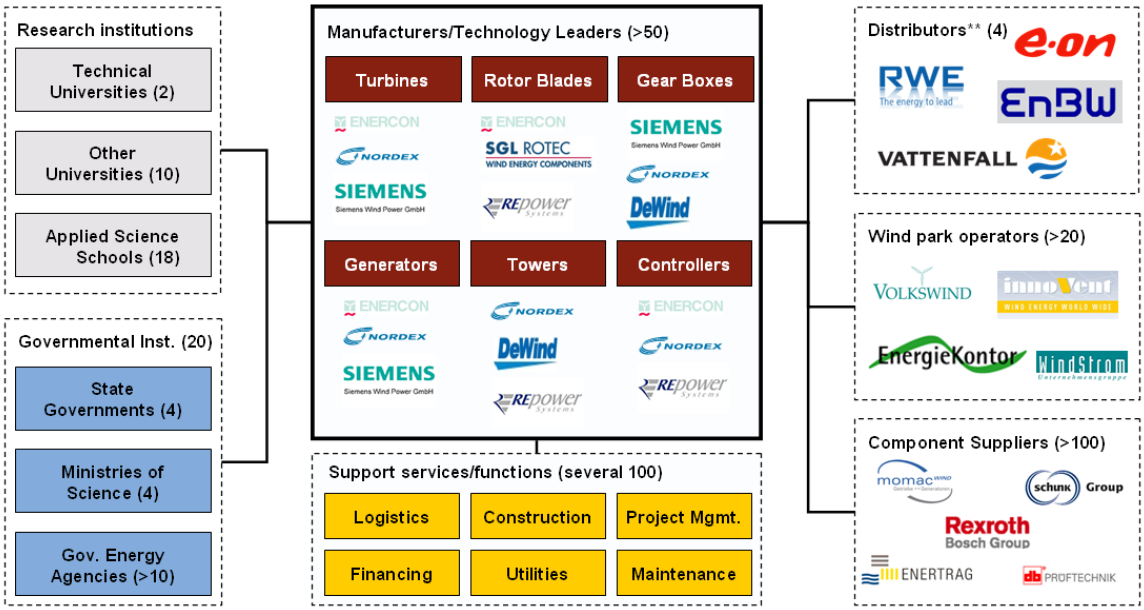



*Exhibit 1: Wind Technology Cluster Map Northwest Germany (2009)*

The authors of this paper estimate that more than 80% of all relevant actors in the cluster are located in a radius of 100 miles around the city of Bremen. The nucleus of the cluster consists of

several dozens of technology leaders that often command fine market shares in their segment. Many span the entire value chain of wind technology from developing and manufacturing turbines to controllers, from rotor blades to gear boxes. An example of such a company is Enercon, located in the town of Aurich in Lower Saxony. Enercon, founded only in 1984 and still privately held today, holds 40% of all worldwide patents in wind technology and has emerged as the most dominant German player worldwide (Simon, 2009). With revenues of EUR 3.15 billion in 2008, almost 13,000 employees, and an export share of more than 60% Enercon towers above the German wind cluster as an icon of innovative wind technology engineering (Enercon homepage, 2010). Enercon today builds the world's largest wind towers and the most powerful turbines and looks back on an impressive 14 GW in total installed capacity. Several other leaders have emerged next to Enercon including but not limited to Nordex, SGL Rotec, RePower (acquired by Indian player Suzlon in 2007 but continues to be headquartered in the cluster), and DeWind (acquired by American player Composite Technologies in 2006 but also continues to be headquartered in the cluster).

The nucleus of technological leaders is closely embedded into a network of energy distributors, wind park operators, and component suppliers. The primary energy distributor in the relevant states, E.On., as discussed earlier is obligated by law to feed wind energy into its distribution system. Other companies that operate distribution networks outside the cluster but that are closely connected with E.On's power network are RWE, EnBW, and Vattenfall.

Companies such as Volkswind, Innovent, EnergieKontor and WindStrom complete the value chain by operating large wind parks that contribute up to 50% of the total energy consumption within their regional context (various company homepages, 2010). The landscape in Northwest Germany has long been shaped by the image of wind towers that are located across the countryside. Wind park operators from the Northwest now expand beyond their home states into offshore parks and other regions in Germany.

Finally, a strong set of component suppliers, some of which admittedly are located outside of the cluster, provide the necessary parts for manufacturing world class wind towers and turbines. Companies such as momac, the Schunk Group, Bosch Rexroth, Enertrag, and DB Prüftechnik are either fully specialized in renewable energies or operate divisions that specifically cater to the needs of wind technology companies. Their products range from controlling modules for turbines to software systems for managing the energy feed in to the distribution networks.

In conclusion, the cluster map indicates a healthy interaction between key players ranging from core technology manufactures to institutes that conduct fundamental research. Several efforts are under way to further strengthen interactions of players within the cluster. A strong agglomeration advantage driven by the cluster's benefits becomes apparent. This agglomeration advantage is likely going to attract more players to the cluster and further grow its prominence not only in Germany but within the global wind technology industry.

***Key growth trends*:** Several German companies were able to fortify their market share position in the decade from 1995 to 2005. While in 1995 only three German players – Enercon, Tacke, and Nordex – held global market shares in the top 10, today five companies that are headquartered in Germany are on the list (BTM Consulting, 2008). GE wind, which emanated from the acquisition of Tacke by General Electric and which is regarded as an American-German joint venture continues to be headquartered in Salzbergen, Lower Saxony. With their strong export orientation, German companies face strong opportunities to grow further and strengthen their market share positions. At the same time, the cluster faces several challenges that could slow down further growth or even develop into more serious threats. In what follows, the key growth opportunities for the German wind technology cluster are outlined and a brief outlook for the near future is provided.

The global wind technology industry is currently experiencing a trend towards larger wind towers and more sophisticated wind turbines. This development has partly been necessitated

because regions with strong winds are already saturated with respect to the number of wind towers they can host. Regions with less wind require larger towers and more complex wind turbines . In both segments, Germany is a leader with Enercon being the producer of the largest wind towers in the world.

Furthermore, a general trend towards offshore wind parks can be observed. Offshore wind parks do not impact the general landscape and as such experience higher acceptability within the population. The German offshore market is currently expected to be the largest together with the UK (Schmidt, 2008). Again Germany benefits from strong demand in a key growth segment that is expected to further drive growth of German players. At the same time, however, regulation enforces stricter policies for offshore wind parks. Due to the national park "Wattenmeer" (a part of the North Sea known for its strong tides and unique ecosystem) wind towers may only be placed in the sea with a distance to the coastline of 40 to 100 kilometers. This distance necessitates the development of particularly effective and large wind towers and turbines. Again, regulation for the better or the worse is forcing German companies to spearhead innovation in this segment (Schmidt, 2008).

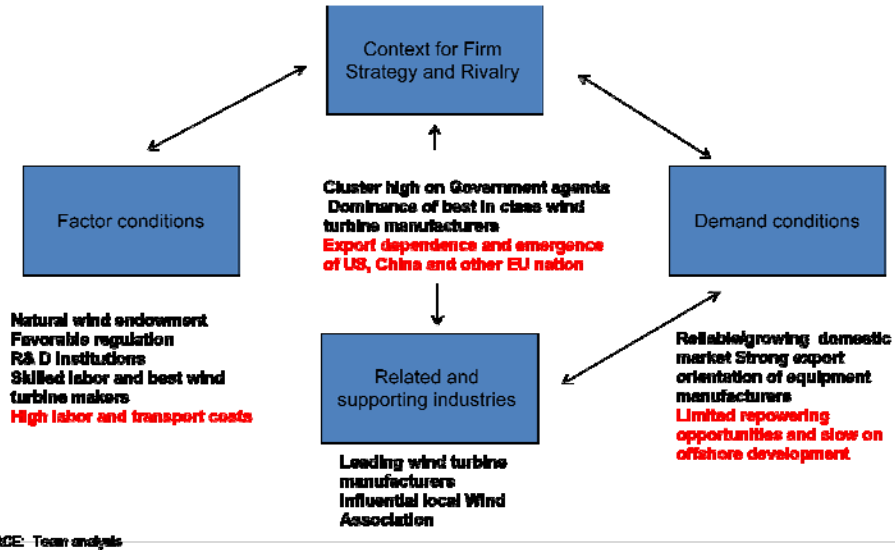
Finally, repowering has emerged as a substantial topic in the wind industry. The retrofitting of existing towers to state-of-the art technology holds significant revenue potential for established players (Global Wind Energy Council, 2009). This growth trend, however, is expected to have a more or less equal impact on all players and does not particularly favor German companies.

With these growth trends in mind it appears the German wind technology cluster is in reasonably good shape to compete in the future. Nevertheless, the cluster also faces a series of challenges that range from unfavorable policy making to competitive threats emanating from India and China. The discussion of these challenges, however, is left to the next section that elaborates on the cluster diamond.

## 2.2. Cluster Competitiveness Analysis: The Diamond Model

An analysis of the German wind cluster diamond reveals that it is a strong diamond and one where elements of the diamond re-enforce each other. Two critical elements of the diamond that have held it in good stead are its (a) Factor conditions – these have been both of high quality and highly specialized (b) Context for firm Strategy and Rivalry – Germany's local context has encouraged appropriate forms of investment and sustained upgrading amongst companies engaged in manufacturing. Even though, the sector is dominated by the German majors, competition has resulted in the emergence of some (smaller) locally based rivals and robust Related and Supporting Industries. Interestingly, it is the above two components of the diamond that are being challenged most by the emergence of China, India and other countries who could produce wind power and its components at a lower cost. However, Germany's specialized factors such as those integral to innovation and upgrading (Technical University of Hamburg-Harburg and the Technical University of Braunschweig and ForWind) offer it some interim protection by fostering higher levels of productivity viz. a viz. China and India and such know-how is also less easily "aped". Secondly, countries with strong manufacturing bases such as Spain and India have a number of locally based rivals that have a presence across the wind energy value chain. However, the rules, incentives and norms that govern the type and intensity of local rivalry are still evolving and the pace of investment is still slow when compared to Germany.

**Germany's Wind Cluster Diamond**




SOURCE: Team analysis

***Factor Conditions***: Germany lends itself to wind parks because of a very strong natural wind endowment. For example, Germany's Wind Profile on the German Wind Index of 1995 codes much of the country in "green" with an average wind index of approximately 95. The country is also home to the world's preeminent local wind turbine and component manufacturers of which many specialize in the production of very large wind turbines. Three out of the top ten global wind turbine manufacturers are German and this includes Enercon (19,000 MW of installed capacity), GE (15,000MW) and Nordex (5,400MW). Until recently, REpower (3,00MW) was also a German manufacturer but it has recently been acquired by India's Suzlon. Third, Germany has ample availability of technically skilled labor combined with universities and technical institutes that produce best in class R&D and technology that enables superior German productivity in turn allowing German turbines to regularly exceed international standards. For example, in 2008, most German turbines were of 2-3MW while the industry standard was 1.5MW. The 30 Research Institutions at all levels from technical universities to applied science schools ensure German manufacturers have access to the latest technology and R&D. Finally, even in tighter credit markets such as those we have just witnessed, competitive financing options have continued to spur investment and increased productivity. According to the German Wind Association, in 2011, Germany will invest €2.2bn in the wind energy market.

Despite the fact that German factor inputs are of superior quality and highly specialized, it faces some competitive disadvantages in the time to come. Wind endowment in Germany is mostly restricted to the North. In the last two years, there has also been a decrease in the number of onshore wind farm sites commissioned and environment concerns have slowed down offshore wind park development. Even more worrying is the fact that Germany may have a serious shortage of workers (particularly service technicians) if the GWE prediction of 22,000MW of onshore capacity and 10,000 MW of offshore capacity by 2020 holds. Training schools like BZEE are already at capacity with increasing influx of technicians sent by UK and Spain. Finally, as wind energy gets commoditized, Germany's higher transportation/logistics and

labor costs maybe a disadvantage. Production may move away from Germany or as recent evidence as illustrated German manufacturers may themselves set up bases outside of Germany in countries like US and India.

***Context for Firm Strategy and Rivalry*:** The wind energy cluster (and the renewable energy sector in general) is an area high on the Government agenda given the new EU Renewable Energy Directive. Germany has agreed to a legally binding renewable energy target of 20% by 2020. This ensures the Government continues to play a pro-active role in promoting the cluster. Historically and until today, co-ordination between the government, businesses and end consumer in the cluster has been very strong. This has at times involved fiscal, financial and regulatory measures where the Government has adapted to changing market conditions and been responsive to the needs of the private sector. As already mentioned above, there is a dominance of large wind turbine manufacturers and though some may argue that this has reduced the intensity of local rivalry there is no doubt that the competition is centered around innovation and high rate of investments, both evidence of an advanced and innovation focused cluster. Thus, on both dimensions of context for firm strategy and rivalry Germany scores well. First, the focus on investment has led to sophisticated competition and higher levels of productivity. Here macro-economic factors and political stability have been supplemented by microeconomic policies most notable that of a favorable corporate governance system. Secondly, as the "Country Analysis" has demonstrated, Germany's openness to trade and foreign investment, strong anti-trust policies, and the lack of corruption have played a pivotal role in the intensity of local rivalry.

However, as mentioned above, the emergence of US and China as serious contenders is challenging Germany's dominance of the sector. Together US and China, account for over 50% of the new capacity installed in 2008. As per the 2008 Global Wind Energy Report, the US installed base at 25,170MW exceeds Germany's at 23,903 MW as of 2008. In addition, the

"second wave" of European countries is playing catch up to Germany. There are now 10 European countries with more than 1,000MW of installed capacity. The threat of a "copy cat" approach by lower cost countries could also challenge German manufacturers most of whom are largely dependent on exports. The changing market structure in term of the balance between "offshore" vs. "onshore" is also likely to impact the competitive dynamics.

***Related and Supporting Industries*:** The German wind cluster has significant presence of both locally based suppliers and competitive related industries. As the Cluster Map has demonstrated, Germany has a preponderance of over 50 best in-class manufacturers and technology leaders engaged in manufacturing all components from turbines and rotor blades to the gear boxes and the towers/generators. They are supported by 4 key distributors most notably E-On and RWE; over 20 wind park operators and over 100 very specialized component suppliers. In addition, there are several hundred firms engaged in support services and functions that range from construction and project management to financing and maintenance.

Germany also has the largest and one of the most influential local Wind Associations that plays a key role in providing expertise, information sharing and best practices. Finally, a thriving broader renewable energy space has also offered synergies in the promotion of the wind energy cluster.

***Demand Conditions*:** Germany has both a large and a sophisticated domestic market. As highlighted above, the early and favorable domestic regulation by the Government has played a pivot role here. According to predictions by the German Wind Association, wind energy could generate as much as 25% of electricity consumption in the country by 2020. Overall, they predict Germany's onshore capacity could be 45,000MW with an additional 10,000MW offshore by 2020. Germany has for many years also been a "feeder" to Europe which has the largest installed wind power capacity. This proximity to the region and their perception of Germany as a leader in the space, gives it easy access to an external market. Germany also has large equipment export potential to nations that are building their wind energy bases prompted by initiatives like

Kyoto. German manufacturers already account for over quarter of global production of €25bn and export over 80% of the equipment they produce.

Two other factors, namely the move towards repowering and increased momentum towards offshore development are also likely to boost demand in the coming years. According to estimates by the German Wind Association, by 2015, 6,000MW of existing capacity could be from repowering. They also predict offshore capacity of 500MW by 2010 and 3GW by 2015.

Inspite of a thriving domestic market and huge export potential, Germany needs to be cautious on some accounts. We have already mentioned that installed capacity is rising fast in many nations and the rest of Europe (many starting from a lower base than Germany) is catching up rapidly. Moreover, the potential for repowering in Germany may not be as large as initially estimated. Only 152MW of capacity is older than 15 years and as of 2008, there was only 24MW of new repowering capacity. Further, the Government is yet to come up with a clear framework for offshore wind farms. The current regulation that mandates parks to be 20-60km offshore in water 20-40m deep is hampering development of such parks. Also, project licensing has been slow with only 23 licenses granted as at the end of 2008.

***Cross Country Comparison of Germany vs. Spain and India*:** Comparing Germany's wind cluster diamond to that of Spain and India's is an interesting exercise. Like Germany, both these countries have strong manufacturing bases and an increasing presence in the global wind technology sector. However, the analysis reveals that Germany's advanced and market friendly regulatory system coupled with innovation driven technical expertise ensures a stronger diamond in Germany. Though Spain has a growing internal demand and presence of some strong turbine manufacturers, the regulatory framework pertaining to wind energy is still evolving and technical/R&D skills in the sector are less developed when compared to Germany. India, no doubt has a huge market potential given the country's reliance on fossil fuels and a strong manufacturing based anchored around Suzlon. However, the country still lacks a national policy for renewable energy.

In Spain, the renewable energy sector is high on the government's agenda given its significant contribution to national GDP. Similarly, if India is to maintain its GDP growth in the 7-9% range and diversify its energy sources away from fossil fuels, renewable energy will be critical. The Government has recently set up a Ministry of Renewable Energy. Demand conditions in both countries are also ripe – Last year Spain achieved 11% y-o-y growth in energy consumption from renewables and set a target of 20,000MW for 2010. However, the country still lacks a clear regulatory framework on renewables. India's witnessed a 22% growth in installed wind capacity in 2008. In addition, the various states have introduced preferential tariffs and fiscal and financial incentives to promote the cluster. Inspite of this, a policy at the national level is still lacking.

Both Spain and India have Related and Supporting Industries but the "depth" and "sophistication" of its cluster map in terms of component manufacturers, distributors, wind park operators and research institutions is still limited compared to Germany. R&D initiatives are slow to come about and in India, as in most emerging economies, firms compete on cost which limits new investment aimed at increasing productivity and the innovative capacity of the cluster. Finally, factor conditions in both countries are conducive. Spain has the largest wind farm owner (Iberdrola) and large turbine manufacturers such as Gamesa Eolica, Acciona Energy etc. However, technical expertise in term of an adequate supply of high skilled labor is limited and cluster growth is hampered by capital constraints. For instance, in 2008, the R&D spend for the sector was only €300m. India has a strong wind endowment especially in the South around Tamil Nadu, a solid domestic manufacturing base around Suzlon and an educated and technical labor force with a high proportion of engineers. That said, the cluster faces R&D and capital constraints. Events like the recent acquisition of REpower by Suzlon could enable India to rapidly bridge the R&D and technology gap and compete with German companies.

***Key Risks to Cluster Development*:** There are five key risks to development of the German wind energy cluster. The first is the potential saturation of the domestic market. Wind power penetration is already greater than 50% in some areas and it is difficult to improve upon this with adequate storage capacity. Also, the less favorable areas or offshore (which remain heavily regulated), is limiting growth viz. a viz. other countries. Second, some estimates suggest that there already exists significant overcapacity in the industry on account of large capital expenditures by manufacturer's pre-crises. The oversupply is expected to last till 2014. This would suggest a move towards price based competition in relative terms viz. viz. emerging countries. Third, as mentioned above, the threat of low cost countries such as India and China with booming manufacturing sectors and companies like Goldwind (#10 global manufacturer) and Suzlon (#6 global manufacturers) cannot be overlooked.

Fourth, the USA can also emerge as a strong contender to Germany's technological leadership. Already, strong domestic demand in the US has led to it surpassing Germany as the largest installed capacity. The presence of GE has fortified access to technology and know-how and Obama's policy is likely to spur heavy investment in local R&D and manufacturing capacity. The weak USD and strong Euro is also likely to impact demand in the short term. Finally, the changing market structure in terms of the balance between onshore and offshore can also pose a challenge. Naturally, a move to offshore (similar to Norway) positions Germany better to compete with competition that is increasingly catching up with onshore technology. However, as described above, the industry is likely to remain onshore at least till 2015 with offshore taking off meaningfully only after this.

## 3. Recommendations

**3.1 Country recommendations:** To address the competitiveness issues identified in the previous chapters, Germany needs to implement two sets of reforms: one aimed at correcting problems related to the business environment under which companies operate, which is

considered over-regulated; and another aimed at correcting the macro-economic imbalances that the German economy faces before they seriously start to undermine competitiveness.

On the first set of reforms, four measures are critical:

(1) Further liberalizing the labor markets: despite the difficult measures introduced under the Agenda 2010 reforms, labor markets are still perceived as rigid and over-regulated and need to be further liberalized;

(2) Reduce excessive taxation and regulations: taxes and regulations are considered high and very distortive and need to be gradually reduced. Attention needs to be given to any fiscal imbalances to ensure that increased incentives for companies will increase economic activity and won't hurt overall tax revenues. Some reforms have already been introduced such as a recent corporate tax from 30% to 15% but are insufficient;

(3) Reforming education system: Germany needs to re-evaluate if the current decentralized education model is appropriate. More incentives need to be put in place for students to pursue higher education, since university graduates are likely to face a shortage in the medium term. Improvements in the quality of education of math and science also need to be made, for example through further investment in IT and laboratories at schools;

(4) Finally seed capital needs to be provided to entrepreneurial firms, ideally though venture capital markets. The Federal and State governments could take a lead in proving the viability of this market by co-financing companies with the private sector in cases where benefits to society are expected though a special fund.

On the second set of reforms, aimed at correcting longer-term imbalances, three key measures are necessary:

(1) Economists agree at large that domestic consumption and investment needs to represent a larger role in the German Economy to reduce its dependence on exports. To achieve this goal fiscal policy should be used extensively. Slight modifications to the tax system could

make it more attractive for families to spend on durable goods (e.g. though tax rebates) and for companies to invest (e.g. though R&D tax breaks).

(2) Difficult reforms need to be made to reducing the mounting costs of the German welfare system. Specific efforts have been made on health care, were Germany is already the fourth biggest spender in per capita terms in the world, but the pension system needs to be addressed, either by further increasing retirement age or reducing benefits.

(3) To counter the demographic inevitability of an ageing population and its implications on growth and social costs, besides providing higher tax incentives for families with babies, Germany needs to fully embrace immigrants in its workforce. This would provide a medium term increase in taxes to feed rising pension costs and increase the number of workers available in the economy. To do so successfully Germany needs to do a serious effort to assimilate its immigrant communities, which remain siloed from society (particularly the important Turkish community).

**3.2 Cluster recommendations:** German Manufacturers, the trade associations, and the government should cooperate to ensure that the cluster maintains its global competitive position, especially against the incoming clusters in Chicago, Montreal, Texas, China, India and Spain. Specifically, the cluster needs to leverage the high level of German expertise in high-tech, large onshore turbines, and the strong opportunities offered by the new offshore demand in northern Europe, while slowly moving away from small commoditized products, that can be outsourced.

1. **Improve R&D and capacity investments in large turbines and off shoring**

Considering that the market demand for small onshore turbines is moving away from Germany, and that German manufacturers are leaders in IP and production of large, sophisticated turbines, the cluster should continue to invest their technological advantage in the segment. Successfully strengthening the cooperation amongst players, and especially between

manufacturers, suppliers and research centers/universities becomes a key factor for success. From a practical standpoint:

(a) The government might offer to match (to ask how to do this within the EU regulations) up to a certain % of the joint R&D spending put forward by groups of 2 or more companies. It can also provide additional funding for Universities focusing in these areas, and provide incentives for the requalification of automotive, aerospace and naval workers that can rejoin the workforce in the wind industry specializing in the growing offshore segment.

(b) Universities should focus their efforts in solving the technological gap (in terms of blades, rotors, and especially grid connection) between the type of turbines required by European countries to reach their 2020 targets (larger onshore and offshore turbines) and what is currently on the pipeline of the main German manufacturers.

(c ) The existing IFCs (e.g. BWE, German Wind, WAB) should continue to facilitate joint R&D projects, particularly in the following six areas: rotor blades, powertrain, foundations and tower modularity and weight, offshore service and logistics, education and grid connection.

- The IFC can act as a facilitator, setting up a team of experts to pick the most promising research topics, and asking each company to contribute one or two employees for cross-research. Pre-defined Joint Ventures can then be incorporated as soon as the new IP becomes usable for mass production.
- Increasing the collaboration with the Energy companies and the providers or Electric transmission and generation hardware (e.g. Siemens) will be particularly useful to develop improved grid connections solutions for offshore power plants might also prove to be a key advantage in the long run.

2. **Align policymaking to sustain the domestic market along this two trends** In order to successfully incentivize innovation, the government should find a way to balance offshore regulation with social good, much in the way the UK opened up vast areas of their coasts to

offshore wind parks. Moreover, the incentive system for onshore repowering should be improved in order to focus incentives on the upfront capital costs required by larger turbines

**3. Develop joint ventures in lower cost countries for the production of smaller turbines**

The Suzlon acquisition of REPower has opened the way to a potential consolidation trend where the lower cost manufacturers might potentially disrupt the more established players, unless the latter ones don't act first. The worrisome growth of Indian and Chinese players could be balanced if German companies would:

- Set their own global footprint so as to keep the R&D process and the production of the most advanced products (larger turbines, full nacelles) in the country, while serving the increased demand for lower-cost turbines from delocalized assembly plants
- Set up supply chain agreements with foreign component suppliers and assembly contractors to source and assemble the towers (mainly steel, lower technological content) as close as possible to the end markets, in order to save on logistics and create a portion of the total cost that varies with the local price level and exchange rate
- Evaluate potential Joint Ventures or acquisitions of manufacturing bases in developing markets, specifically India and China. (to be understood how they are serving the US)

Analyzing the cluster development and the expected industry trends it is clear to see how Germany and the German Wind Power Cluster will have to act in order to preserve its current competitive strength in the global markets, and eventually reposition itself as a competitive high-tech knowledge powerhouse which is able to take full advantage of extended supply chains, reduced logistics and import tariffs, and delocalization in LCC trends.

## Exhibit 1: Macro-economic Indicators, 1991-2009

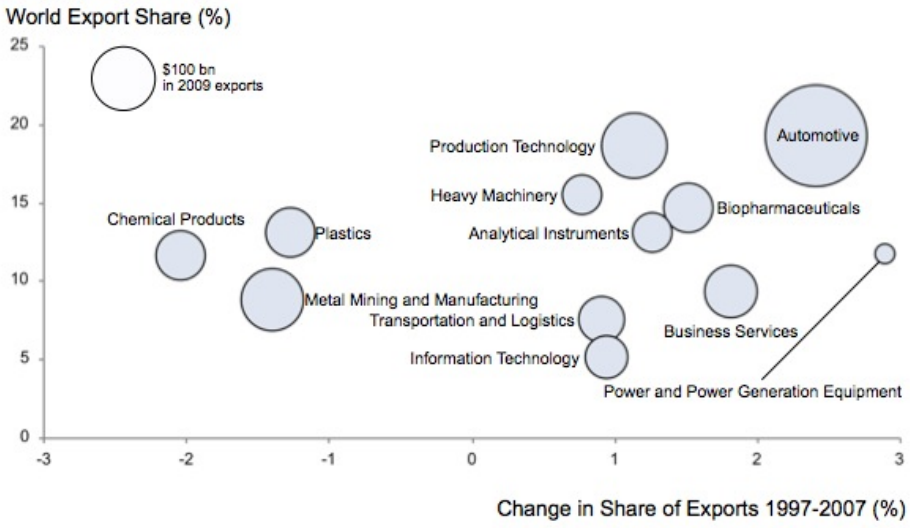
| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Real GDP growth per head (% pa) | 14.9 | 1.3 | -1.2 | 2.4 | 1.5 | 0.8 | 1.7 | 2.1 | 1.9 | 3.1 | 1.0 | -0.1 | -0.2 | 1.2 | 0.8 | 3.1 | 2.4 | 1.1 | -5.0 |
| **Real expenditure (bn EUR at 2000 prices)** | | | | | | | | | | | | | | | | | | | |
| Real GDP | 1,761 | 1,800 | 1,785 | 1,833 | 1,867 | 1,886 | 1,920 | 1,959 | 1,998 | 2,063 | 2,088 | 2,088 | 2,084 | 2,109 | 2,125 | 2,192 | 2,246 | 2,274 | 2,161 |
| Real private consumption | 1,024 | 1,058 | 1,066 | 1,087 | 1,111 | 1,126 | 1,135 | 1,152 | 1,186 | 1,214 | 1,237 | 1,227 | 1,229 | 1,230 | 1,234 | 1,250 | 1,245 | 1,250 | 1,255 |
| Real government consumption | 332 | 349 | 350 | 359 | 366 | 374 | 376 | 382 | 387 | 392 | 394 | 400 | 401 | 398 | 400 | 404 | 411 | 419 | 431 |
| Real gross fixed investment | 377 | 394 | 377 | 393 | 393 | 390 | 394 | 410 | 430 | 442 | 426 | 400 | 399 | 398 | 401 | 433 | 455 | 469 | 429 |
| Real stockbuilding | 32 | 19 | 13 | 15 | 21 | 8 | 9 | 15 | 10 | 7 | -12 | -24 | -14 | -14 | -23 | -29 | -32 | -23 | -37 |
| Real exports of G&S | 413 | 410 | 390 | 421 | 448 | 475 | 530 | 572 | 606 | 688 | 733 | 764 | 783 | 863 | 930 | 1,050 | 1,129 | 1,162 | 989 |
| Real imports of G&S | 411 | 423 | 403 | 436 | 464 | 481 | 520 | 570 | 618 | 681 | 689 | 680 | 716 | 768 | 819 | 917 | 961 | 1,002 | 913 |
| **Contribution to real GDP growth (% points)** | | | | | | | | | | | | | | | | | | | |
| Private consumption | 12.0 | 1.9 | 0.5 | 1.2 | 1.3 | 0.8 | 0.5 | 0.9 | 1.7 | 1.4 | 1.1 | -0.5 | 0.1 | 0.1 | 0.2 | 0.7 | -0.2 | 0.2 | 0.2 |
| Government consumption | 4.1 | 1.0 | 0.0 | 0.5 | 0.4 | 0.4 | 0.1 | 0.4 | 0.2 | 0.3 | 0.1 | 0.3 | 0.1 | -0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 |
| Gross fixed investment | 4.7 | 1.0 | -0.9 | 0.9 | 0.0 | -0.1 | 0.2 | 0.8 | 1.0 | 0.6 | -0.8 | -1.2 | -0.1 | -0.1 | 0.2 | 1.5 | 1.0 | 0.6 | -1.8 |
| Stockbuilding | -0.1 | -0.8 | -0.3 | 0.1 | 0.3 | -0.7 | 0.1 | 0.3 | -0.3 | -0.2 | -0.9 | -0.5 | 0.5 | 0.0 | -0.4 | -0.3 | -0.1 | 0.4 | -0.6 |
| External balance | -5.2 | -0.8 | 0.0 | -0.1 | -0.1 | 0.6 | 0.8 | -0.4 | -0.8 | 1.0 | 1.7 | 2.0 | -0.8 | 1.3 | 0.7 | 1.1 | 1.6 | -0.4 | -3.7 |
| **Structure of GDP (%)** | | | | | | | | | | | | | | | | | | | |
| Private consumption | 57.3 | 57.5 | 58.2 | 57.9 | 57.7 | 58.2 | 58.2 | 57.9 | 58.4 | 58.9 | 59.6 | 59.0 | 59.4 | 58.9 | 59.1 | 58.3 | 56.6 | 56.5 | 58.3 |
| Government consumption | 19.1 | 19.6 | 19.6 | 19.5 | 19.6 | 19.8 | 19.4 | 19.1 | 19.2 | 19.0 | 18.9 | 19.2 | 19.3 | 18.8 | 18.7 | 18.3 | 17.9 | 18.1 | 19.7 |
| Gross fixed investment | 23.2 | 23.6 | 22.5 | 22.6 | 21.9 | 21.3 | 21.0 | 21.1 | 21.3 | 21.5 | 20.0 | 18.3 | 17.9 | 17.5 | 17.4 | 18.2 | 18.8 | 19.0 | 18.1 |
| Stockbuilding | 0.7 | -0.2 | -0.3 | -0.1 | 0.3 | -0.2 | 0.1 | 0.5 | 0.2 | 0.3 | -0.5 | -1.1 | -0.5 | -0.4 | -0.5 | -0.5 | -0.4 | 0.2 | -1.0 |
| Exports of G&S | 25.8 | 24.1 | 22.3 | 23.1 | 24.0 | 24.9 | 27.5 | 28.7 | 29.4 | 33.4 | 34.8 | 35.7 | 35.6 | 38.4 | 41.1 | 45.4 | 46.9 | 47.3 | 40.7 |
| Imports of G&S | 26.2 | 24.5 | 22.3 | 22.9 | 23.5 | 24.0 | 26.2 | 27.3 | 28.5 | 33.0 | 32.8 | 31.2 | 31.7 | 33.3 | 35.8 | 39.7 | 39.9 | 41.0 | 35.8 |
| **Growth, productivity and wages** | | | | | | | | | | | | | | | | | | | |
| Labour productivity growth (%) | -14.7 | 3.7 | 0.5 | 2.8 | 1.7 | 1.3 | 1.9 | 0.8 | 0.7 | 1.3 | 0.8 | 0.6 | 0.7 | 0.8 | 0.9 | 2.5 | 0.8 | -0.1 | -4.9 |
| Total factor productivity growth (%) | -8.8 | 1.9 | -1.2 | 1.9 | 1.0 | 0.5 | 1.3 | 0.7 | 0.6 | 1.4 | 0.3 | -0.2 | 0.1 | 0.6 | 0.5 | 2.4 | 0.9 | -0.3 | -5.2 |
| Growth of real capital stock (%) | 3.8 | 3.5 | 3.6 | 2.5 | 2.2 | 1.9 | 1.6 | 1.6 | 1.6 | 1.6 | 1.8 | 1.5 | 0.8 | 0.9 | 0.9 | 1.1 | 1.4 | 1.8 | 0.6 |
| Average real wages (% change pa) | -11.8 | 3.8 | 1.0 | 0.4 | 3.0 | 1.3 | -0.2 | 0.3 | 1.4 | 1.9 | 0.4 | 0.7 | 0.9 | -1.5 | -0.9 | -0.4 | -1.5 | -0.4 | 2.7 |
| **Fiscal and monetary indicators** | | | | | | | | | | | | | | | | | | | |
| Budget balance (% of GDP) | -3.0 | -2.5 | -3.0 | -2.3 | -9.7 | -3.3 | -2.6 | -2.2 | -1.5 | 1.3 | -2.8 | -3.7 | -4.0 | -3.8 | -3.3 | -1.6 | 0.2 | 0.0 | -3.2 |
| Public debt (% of GDP) | | | | | 55.6 | 58.4 | 59.6 | 60.4 | 61.0 | 59.7 | 58.7 | 60.2 | 63.7 | 65.9 | 68.1 | 67.6 | 64.9 | 66.0 | 72.0 |
| GDP deflator (% change; av) | 1.6 | 5.0 | 3.7 | 2.4 | 1.9 | 0.5 | 0.3 | 0.6 | 0.3 | -0.7 | 1.2 | 1.4 | 1.2 | 1.0 | 0.7 | 0.5 | 1.9 | 1.5 | 1.5 |
| Consumer prices (% change pa; av) | 4.2 | 5.1 | 4.4 | 2.8 | 1.7 | 1.4 | 1.9 | 1.0 | 0.5 | 1.5 | 2.0 | 1.3 | 1.1 | 1.7 | 1.5 | 1.6 | 2.3 | 2.6 | 0.3 |
| Exchange rate EUR:US$ (av) | 0.81 | 0.77 | 0.85 | 0.84 | 0.76 | 0.79 | 0.88 | 0.89 | 0.94 | 1.08 | 1.12 | 1.06 | 0.88 | 0.80 | 0.80 | 0.80 | 0.73 | 0.68 | 0.72 |
| **Demographic Indicators** | | | | | | | | | | | | | | | | | | | |
| Population (m) | 80.3 | 81.0 | 81.3 | 81.5 | 81.8 | 82.0 | 82.1 | 82.0 | 82.2 | 82.3 | 82.4 | 82.5 | 82.5 | 82.5 | 82.5 | 82.5 | 82.6 | 82.7 | 82.8 |
| Labour force (m) | 40.4 | 41.0 | 41.0 | 41.2 | 41.2 | 41.5 | 41.9 | 42.2 | 42.5 | 43.0 | 43.2 | 43.2 | 43.1 | 43.3 | 43.7 | 43.6 | 43.5 | 43.5 | 43.7 |
| Recorded unemployment (%) | 8.3 | 7.7 | 9.0 | 9.6 | 9.5 | 10.4 | 11.5 | 11.1 | 10.5 | 9.6 | 9.4 | 9.8 | 10.5 | 10.6 | 11.7 | 10.8 | 9.0 | 7.8 | 8.1 |
| **Select Balnace of Payments Indicators** | | | | | | | | | | | | | | | | | | | |
| Current-account balance/GDP | -1.21 | -1.01 | -0.88 | -1.40 | -1.15 | -0.50 | -0.36 | -0.63 | -1.26 | -1.69 | 0.02 | 2.03 | 1.92 | 4.66 | 5.12 | 6.52 | 7.90 | 6.65 | 4.10 |
| Inward direct investment (US$ m) | 4,750 | -2,120 | 400 | 7,290 | 11,990 | 6,430 | 12,800 | 23,640 | 55,910 | 210,090 | 26,170 | 53,610 | 30,930 | -9,800 | 46,470 | 58,130 | 56,500 | 21,250 | -6,606 |
| Outward direct investment (US$ m) | -22,980 | -18,730 | -17,140 | -18,940 | -39,100 | -50,750 | -42,720 | -89,930 | -108,670 | -59,740 | -39,250 | -19,630 | -5,150 | -19,960 | -76,960 | -127,770 | -181,280 | -158,130 | -49,695 |
| Net direct investment flows (US$ m) | -18,230 | -20,850 | -16,740 | -11,650 | -27,110 | -44,320 | -29,920 | -66,290 | -52,760 | 150,350 | -13,080 | 33,980 | 25,780 | -29,760 | -30,490 | -69,640 | -124,780 | -136,880 | -56,301 |

## Exhibit 2: Select GCI Rankings where Germany ranks below 40th place

| | 2009 Ranking (Out of 133 countries) |
|---|---|
| **Global Position** | **8** |
| **Factor (Input) Conditions** | **16** |
| *Administrative infrastructure* | *49* |
| (Low) Burden of government regulation | 88 |
| Ease of starting a new business | 70 |
| (Low) Number of procedures required to start a business | 75 |
| (Low) Time required to start a business | 53 |
| Doing Business, Paying Taxes (Low) Payments number (WB) | 45 |
| *Capital market infrastructure* | *37* |
| Soundness of banks | 116 |
| Ease of access to loans | 67 |
| Venture capital availability | 63 |
| Financing through local equity market | 55 |
| *Innovation infrastructure* | *20* |
| Quality of math and science education | 41 |
| Tertiary enrollment | 43 |
| **Context for strategy and rivalry** | **16** |
| Pay and productivity | 56 |
| FDI and technology transfer | 86 |
| (Low) Impact of taxation on incentives to work and invest | 100 |
| (Low) Distortive effect of taxes and subsidies on competition | 108 |
| Business impact of rules on FDI | 72 |
| Strength of investor protection | 71 |
| (Low) Rigidity of employment | 89 |

Source: World Economic Forum Global Competitiveness Report 2008-2009

## Exhibit 3: Germany Cluster Map




Source: Prof. Michael E. Porter, International Cluster Competitiveness Project, Institute for Strategy and Competitiveness, Harvard Business School; Richard Bryden, Project Director. Underlying data drawn from the UN Commodity Trade Statistics Database and the IMF BOP statistics.

# IV. Bibliography

Airports Council International, April 15, 2010

BTM Consulting: "World Market Update 208", Annual Report, Ringkoeping, Danmark, 2008.

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit: "Facts and Data on renewable energies – an internet update on selected data" ("Erneuerbare Energien in Zahlen – Internetupdate ausgewählter Zahlen"), Special Report, Berlin, Germany, 2009.

Bündnis '90/Die Grünen: "Parteichronik", Party homepage, accessed on March 30th, 2010, at http://www.gruene-partei.de/cms/gruene_work/rubrik/0/189.chronik.htm

Economist Intelligence Unit, 2010

EIA – US Energy Information Administration, International Energy Statistics, Consumption, http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=2&pid=2&aid=2

Enercon GmbH: "Potential of wind energy", Special Issue, Bremen, Germany, 2008.

Enercon homepage: "Facts and Figures", accessed on March 29th, 2010, at http://www.enercon.de/en/_home.htm

Energy Watchgroup - Wind Power in Context – A clean Revolution in the Energy Sector – Germany, 2008.

Eurostat, 2007

ForWind homepage: "About Us", accessed on March 29th, 2010, at http://www.forwind.de/forwind/index.php?article_id=1&clang=1

German Wind Association: "Wind energy – an energy source with a fantastic future", Special Report, Berlin, Germany, 2009.

German Wind Association: "Wind energy in Germany – a clean issue", Special Report, Berlin, Germany, 2008.

Global Wind Energy Council: "Global wind report 2008", Annual Report, Brusssels, Belgium 2009.

IMD Lausanne, World Competitiveness Yearbook 2010

International Monetary Fund, World Economic Outlook Database, April 2009

Manager Magazin, Hidden Champions: Weltmarktführer aus Deutschland, 11/13/2007

Schmidt, M.: "POWER cluster – the Northern European competence network for offshore wind energy", presentation at windcomm, Kiel, Germany, unpublished, 2008.

Simon, H.: "Hidden champions of the 21st Century", Springer, New York, USA, 2009.

Simon, Hermann, Hidden Champions of the 21st Century, Springer 2009, London, P. 15

Statistisches Bundesamt Destatis (Federal Statistical Office), 2006

The Economist, Special Report on Germany, March 13, 2010

Wind Turbine - Materials and Manufacturing Fact Sheet, Princeton Energy Resources International, LLC. Dan Ancona and Jim McVeigh, 2000.

World Bank, World Development Indicators, 2009

World Economic Forum, Global Competitiveness Report 2009-09

World Wind Energy Association: "World wind energy report 2009", Annual Report, Bonn, Germany, 2009.