DENMARK
– THE WIND POWER HUB;
TRANSFORMING THE SUPPLY CHAIN

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0. Preface

The purpose of this report is to illustrate how global trends in the wind industry have affected the Danish part of the industry. The report will focus especially on the consequences of recent developments for the location and organisation of value chain activities as well as for the strategic challenges and opportunities these developments have created for Danish players in the wind power sector.

In the past five years, the wind industry – encompassing companies and other organisations supplying components and services used in the design and manufacture, installation, investment and operation of wind turbines and wind farms, in their planning, foundation or their electrical or constructional installations – has continued along the global development track that was laid in the mid-2000s. In spite of recent redundancy rounds, developments have been characterised by growth in the number of companies, exports and earnings and great fluctuations, whilst wind power has managed to retain and perhaps even consolidate its position as the most technologically advanced and reliable renewable source of energy compared with other alternative sources of energy. The ability to retain and consolidate this position has attracted major investments to the sector, leading to a globalisation of corporate ownership across the value chain. In a number of ways, this has changed the dynamics in the – still important – part of the global wind industry that is located in Denmark and worldwide.

Another development trend characterising the industry is the growing attention to the costs involved in the energy from wind. As wind is gradually becoming a source of energy considered on a par with energy sources, it is not only assessed on the basis of its environment-friendly impacts, but also on the basis of a Cost of Energy (CoE) consideration. Among other things, this leads to substantial investment relative to the special challenges involved in integrating and using wind power in an expedient and financially feasible manner. One particular challenge lies in integrating the use of wind power to increase the utilisation rate and, by extension, the value of wind power. The challenges occur to a varying degree in different countries. In Denmark, for example, the challenge is that much of the wind power generated cannot be used to the optimum extent because the Danish heat/power sector is not sufficiently flexible to align its capacity to the fluctuating wind energy generation. China is facing the challenge that its power grid is not sufficiently developed, as a result of which about one-third of the MWS installed have not been connected to the grid (BTM, 2011b). This interaction with downstream players – the intermediaries and businesses that mediate energy or use electricity as their driving force – has also left its mark on trends in the wind industry.

The following chapters will explain what impacts the trends have had on value chain relations in the existing Danish wind industry and which future global challenges and opportunities lie in wait for the sector. The report will also describe Denmark’s possibilities for attracting foreign wind power businesses.
The objective is that the report will directly benefit the industry players and that it may form the basis of making more qualified, political decisions on a regional and national scale. The terms of reference of the report were laid down by the Central Jutland Region, the Danish Wind Industry Association and Invest in Denmark.

We would like to take the opportunity to thank the many experts and businesses that have accommodated our request for knowledge and spent time on helping us in preparing this report. We would also like to thank the more than 100 respondents who have filled in our questionnaire, thus providing us with an updated insight into the wind industry. Finally, we would like to thank the Central Denmark Region and the Danish Wind Industry Association for a fruitful collaboration and for their help and assistance.

Poul Houman Andersen and Ina Drejer
SUMMARY

The wind industry is continuing along the expansive growth track that was laid already in the 2000s. Developments have been characterised by great fluctuations, whilst wind power has managed to retain and perhaps even consolidate its position as the most technologically advanced and reliable renewable source of energy compared with other alternative sources of energy. Year-on-year growth in installed wind power capacity is accelerating despite the global economic crisis, and the number of installed MW has almost grown exponentially. In 2010 alone, approximately 24,000 turbines were installed in 50 different countries worldwide (corresponding to 39,400 MW). This progress also means that the production and development hub is moving away from Denmark and Europe towards Asia, which now represents the greatest market potential and the highest production capacity in the world.

In a number of ways, this has changed the dynamics both in the (still important) part of the wind industry that is located in Denmark and worldwide.

- Foreign investments have resulted in increased globalisation of the ownership of the part of the wind industry located in Denmark. Approximately 25% of the industry players are controlled by foreign owners.
- Foreign companies in Denmark act differently than the Danish-controlled companies do:
  - the foreign-controlled companies generate more global revenue and control more international operations than their Danish-controlled counterparts;
  - the foreign-controlled companies have a lower wage component relative to total production costs than the Danish-controlled companies;
  - the non-Danish companies to a greater extent draw on knowledge from Danish and non-Danish universities than the Danish-controlled companies do.

Overall, these factors leave the impression that the Danish-controlled part of the wind industry is being overtaken in key areas. The volume of the industry is a key prerequisite for maintaining an adequately detailed and dynamic division of work in the wind industry. Production flexibility and innovative abilities depend on such division of work. If the Danish-controlled players fail to maintain their pace of development, in the coming years we will see increased hierarchisation among the Danish players, while foreign-controlled suppliers and other players in the wind industry will increasingly take over the positions as critical development partners and attractive workplaces for Danish talent in these fields.

Interviews among suppliers, manufacturers and power companies unequivocally indicate that the structure of production and development operations in the wind industry is changing. Generally speaking, the challenges facing the players of the wind industry derive from the industry’s evolution and maturation process. Competition and collaboration parameters change concurrently with this process. The development of new generations of wind turbines used to be the critical innovation activity, and supplier development skills were pivotal for advances in wind turbine designs. In the past few years, new requirements and priorities
have been added and supplier requirements have changed: requirements for process optimisation, quality management, speed to market, servicing and the ability to form part of and relocate together with the manufacturers’ global production activities. Collaboration in these areas is also undergoing change: the coordination of the supply task has become too complex to handle exclusively through informal relations between suppliers and manufacturers. The ongoing streamlining of logistics systems has led to the emergence of new players specialising in connecting the global value chains.

This report identifies four key challenges facing companies in the Danish wind industry relative to these trends:

1. **Development calls for unlearning**: Supplier flexibility and problem-solving abilities are only to a limited extent appreciated by the well-established Danish wind turbine manufacturers, who increasingly demand process optimisation and consistent products. In addition, the Danish suppliers must increasingly prepare themselves to look beyond Denmark’s borders – both with respect to accessing the latest know-how and with respect to identifying new customers who also seek the suppliers’ traditional “problem-solving skills”.

2. **Excellent subcontractors rely on excellent customer relationships**: Suppliers in the field of production, which remains the backbone of the Danish wind industry, are important and major liaison partners for the manufacturers. As such, if the Danish-based wind turbine manufacturers want to continue to have a highly qualified network of Danish suppliers, customer-supplier relations need to be improved and made more professional. This process requires that both sides make investments and adjustments, and it will combine old virtues such as trust with a higher degree of control and formalised relationships.

3. **Competence profile of suppliers challenged by new forms of collaboration**: Supplier skills are not primarily in the fields of management and globalisation. This part of the suppliers’ competence profile must be developed in the coming years. Suppliers and other players wishing to pursue activities in the wind industry of tomorrow must prepare themselves for the fact that this will require a substantially higher degree of specialisation relative to the industry’s changed requirements. This will call for considerable investment in competence building, organisational changes and revised strategic priorities.

4. **Local competitive strength requires global presence/flexibility**: A key prerequisite for continuing competitive strength among the companies is not only transition but also the ability to capitalise on opportunities to combine global production activities with localisation benefits to a far greater extent and for far more players than is the case today. The players of the Danish wind industry must increasingly acknowledge that they should no longer base their competitive skills exclusively on export base logics in which competitive advantages in the export markets are subject to access to a Danish component and knowledge market. Instead, these players must focus on the ability to group and exploit differences in cost levels and skills developing in the regional markets and combining them in order to create competitive advantages in the local markets where the players
operate. Active exploitation of trade relation opportunities will be the underlying driver of the wind industry in the years to come.

After the challenges, five recommendations are presented in respect of what regional and national commercial policies should focus on if Danish-based companies are to retain a key role in the global wind industry:

- Strengthening export initiatives in emerging markets
- Building skills to participate in global value chains
- Participating in more global knowledge networks
- Promoting process innovation across the value chain
- Exploiting and developing different regional strengths
METHODOLOGY

The analysis is based on 12 interviews with companies in Denmark operating in the wind industry. The companies represent different parts of the value chain, from component suppliers over service and system suppliers to turbine manufacturers and utilities. In addition, we conducted two interviews with wind power scientists from Risø-DTU and Aalborg University, respectively. Most of the companies interviewed are located in the Central Denmark Region, but we also conducted interviews with companies in the Region of Southern Denmark and the Capital Region. The interviews reflect factors such as the diversity of Danish wind power suppliers. This diversity means that the companies must apply different approaches and methods when they address the challenges and act on the opportunities described in this report.

1. Questionnaire: 107 replies/270 companies (Nov-Jan)
2. Interviews (Sep-January)
3. Reports from the Danish Wind Industry Association, IHS, MAKE, BTM, Ronald Berger
4. Special extract from Statistics Denmark

Figure 1: Interviewed companies’ position in the value chain

A web-based questionnaire was filled in by players in the wind industry. The gross list of respondents consisted of members of the trade association under the Danish Wind Industry Association and members of the Danish Export Association’s Wind Energy Group. The gross list has been adjusted for companies and organisations for which no e-mail address could be identified, and for companies which, upon a preliminary enquiry, indicated that the survey was irrelevant for them, or that for other reasons they were unable/unwilling to participate.
The questionnaire was distributed to 269 respondents, 107 of which participated, equal to a response rate of 39.8%. Most of the respondents are small and medium-sized suppliers, but knowledge institutions, planning companies and the like also participated. The large Danish-based turbine manufacturers were not among the respondents to the questionnaire survey, but they have willingly taken part in interviews.

The distributed questionnaire consists of two parts: a general part covering the company’s commitment to the wind industry, its ownership, development plans etc.; a network part, the purpose of which was to identify the company’s acquisition, sales and knowledge relations with other wind power companies located in Denmark. The latter part of the questionnaire thus aims to uncover network and value chain relations between wind power companies in Denmark.

The analysis follows up on a similar analysis conducted in 2006 (See (in Danish only) www.windpower.org/download/856/Danmark_som_Wind_Power_Hub.pdf).
1. The global wind industry in 2012: Current trends

Market trends
Global demand for energy is growing, and growth rates have surged over the past five years. The energy statistics speak for themselves. Measured in terms of energy units (oil equivalents), the global population consumes about twice as much energy today as it did 25 years ago. This development is especially due to a strong increase in production and consumption in the BRIC countries (Brazil, Russia, India, China), which is reflected in their high rates of economic growth. In 2009, China represented more than 17% of the world’s combined energy consumption and was the world’s second-largest importer of crude oil and coal (IEA, 2011c). A number of other countries that in recent years have witnessed rapid economic expansion and a similar surge in energy needs will likely experience similar developments. In 2010, 20% of the world’s population had no access to electricity, and non-OECD countries are expected to account for 90% of the increase in energy demand in the period until 2035 (IEA, 2011a).

Year-on-year growth in installed wind power capacity is accelerating despite the global economic crisis, and the number of installed MW has almost grown exponentially (see Figure 2). In 2010 alone, approximately 24,000 turbines were installed in 50 different countries worldwide (corresponding to 39,400 MW). Although projections always involve some degree of uncertainty, even optimistic estimates of developments in the wind power market such as the forecast in the Wind force 12 scenario, developed by the European industry organisation for wind energy (EWEA), have so far predicted actual developments quite well. Furthermore, estimates of this type can often be validated by information about national policies and investment plans already available. It should be mentioned, however, that three leading consulting firms all point to a growth scenario in the period towards 2015, although their growth predictions differ quite widely (growth rates from about 4% to 13%). Based on a price per installed MW onshore of between DKK 10 and 11 million (for offshore wind power the amount per MW installed is about twice as high), the combined annual revenue in the wind power market in 2012 is therefore estimated at between DKK 100 and 500 billion, rising to DKK 500–1,000 billion by 2015 (BTM, 2011b; MAKEconsulting, 2010).
China has accounted for the strongest growth in terms of MW installed, whilst Europe has recorded moderate growth in the past two years. Europe still has the largest combined volume of installed MW, but in terms of MW installed in 2009 and 2010 the region was overtaken by Asia (primarily China and India). This trend is expected to continue and will reduce Europe’s importance in the global industry, both in terms of installations and manufacturing output. In 2010, four of the world’s ten largest manufacturers were based in China, representing a combined share of the world market of just over 30%. These development trends also reflect the intention of the Chinese government to supply its home market with turbines manufactured domestically.

Disregarding China’s dominant position in terms of growth, developments show that demand is spread across an ever-growing number of countries. Although the ten largest wind power nations still account for 87% of the aggregate capacity, there are now more than 50 countries with established wind power plants, and 20 countries have installed capacity of more than 1,000 MW (BTM, 2011b; GWE, 2011). Historical data and expected developments until 2015 are shown in the charts in Figure 3. As shown in the charts, the Asian markets (primarily China and India) already hold important positions as markets for wind power plants. The region is expected to consolidate and expand this position in the period until 2015. The USA and Europe are both expected to expand and catch up with the expansion momentum of Asia, but Asia is expected to become the biggest market by 2015 – measured both in absolute terms as installed MW and relatively in terms of growth.

Figure 2: Accumulated volume of installed MW – actual and projected
(Source: GWE, 2011, BTM, 2011)
In spite of this positive trend and expansive growth, wind power only retains a limited role as a source of energy. According to the IEA, wind power contributes less than 2% to the world’s aggregate energy production. In Denmark, wind power contributes just under 3% (Danish Energy Authority, 2010).

In the years ahead, capacity growth in Europe will be driven increasingly by offshore projects. Offshore is expected to account for nearly 10% of aggregate demand for “installed MW” by 2015 (BTM, 2011b). As such, there would seem to be ample room for continued expansion of the market and demand for wind power plants and related services within – but especially outside – Europe in coming years. Indeed, a number of drivers are pointing to continuing wind power expansion. However, reducing the average costs (“CoE”) to a
level that matches the cost of other sources of energy is a prerequisite. Overall, this will be impacted by political, economic and social framework conditions and by technological advances and competition dynamics in the value chain. These drivers will be discussed later in the report (chapter 3) and will therefore only be briefly touched upon here:

- The growing energy need of the BRIC countries will drive up prices of fossil fuels and change the price difference per energy unit, or parity, to the benefit of wind power.

- Continuing expansion, development and interconnection of the power grids – including the development of intelligent energy systems – in Europe (and elsewhere) will enhance the possibilities of harnessing the wind more efficiently.

- The political climate favours carbon-friendly energy production, whilst disfavouring a further expansion of nuclear power.

- Trends in the transport industry towards electric vehicles would favour increased use of electricity relative to other sources of energy in the transport sector.

- Technological advances in turbines and the installation and operation thereof reduce the price per kilowatt of wind power.

**Global production of wind turbines**

Market developments, including the projection of demand, remain a key factor in understanding the location and organisation of value chain activities. Local production and demand largely go hand in hand, and there seems to be a connection between establishing local production and building local MW volumes. Many countries have defined clauses and statements of intent to support local procurement and production of components. Greater diversification means longer and more complex value chains. As a result, Denmark is no longer the unrivalled geographic wind power hub but is now one of several geographic hubs in Europe and the rest of the world, like Germany, Spain, India and the USA, for example. In 2007, the European Wind Energy Association estimated that Denmark, Germany and Spain directly employed 23,500, 38,000 and 20,500 people, respectively (EWEA, 2008). In India, it was estimated in 2008 that the wind industry employed 28,400 people (GWEC & Indian Wind Turbine Manufacturing Association, 2009), while the American Wind Energy Association estimated that 85,000 jobs were supported by wind power in the USA in 2009 (AWEA, 2010). Even though differences in calculation methods may make it difficult to directly compare employment figures, they underline the fact that Danish companies and knowledge institutions increasingly participate in a global division of work in the wind power scene. This is reflected also in the distribution of manufacturer market shares.
Developments in the number of manufacturers and their importance to the world market are also reflected in the location of production. Ten years ago, the vast majority of the world’s production capacity was found in northern Europe, with Denmark representing the geographic hub measured in terms of delivered MW. Today, the manufacturing hub has relocated from Europe to Asia. In 2010, production sites in Europe supplied about 41% of new wind power capacity (measured in MW), whilst production sites in China and India combined supplied up to 48%. Most of the Asian production sites were controlled by non-western companies (BTM, 2011a). This proportion is expected to rise in step with the enhancement of skills and expansion of production capacity in Korea, in particular. So far, this trend has been reflected more in a general expansion than in a redistribution of existing production capacity. First of all, especially the Chinese manufacturers have benefited from the strong expansion of Chinese wind power capacity and, secondly, the market was undersupplied in terms of production capacity during a certain period (2006-2009), triggering sharp price increases on MW, whilst also attracting investors to the region. With some delay, these investments are now feeding through, and current global production capacity
is too high relative to demand because the economic crisis has triggered a sharp decline in demand. This has resulted in rationalisation measures among the major manufacturers. Furthermore, developments have led to consolidation and restructuring among key component suppliers and in other parts of the wind industry. The industry has witnessed a flight to quality with the most dubious (in terms of quality) and otherwise poorly performing suppliers – following years of capacity shortage – now being weeded out by the manufacturers (BTM, 2011b).
2. Danish wind industry: A global player?

The globalisation of wind turbine production has also left its mark on Denmark, and for a number of years, the major “Danish” wind turbine manufacturers have fully or partly been under full or part foreign ownership. Going into 2012, Vestas Wind Systems estimated that about 49% of the company’s share capital was held by non-Danish shareholders. The largest single shareholder is BlackRock, the US-based multi-national investment manager. Headquartered in Aarhus, Denmark, Vestas is truly a global player with sales and service facilities on six continents and production and research facilities in Europe, the USA and Asia.

Since German-based Siemens acquired Bonus Energy in 2004, Siemens Wind Power has also been considered a Danish wind turbine manufacturer. This is still the general perception, even though in 2011 Siemens resolved to move its wind power headquarters from Brande in Denmark to Hamburg, Germany. The relocation was made in connection with an operational reshuffle that dissolved the wind turbine business as an independent division of the company. Siemens Wind Power has factories in Denmark, the USA and China.

Whilst Vestas worldwide has largely as many employees as the rest of the Danish wind industry put together (approximately 25,000 people), the global headcount of Siemens’ wind turbine operations, at 8,000, is not quite as spectacular. Whereas the bulk of Siemens’ employees are located in Denmark, Vestas, on account of its very broad global footprint, employs substantially more people outside Denmark.

In addition to Vestas and Siemens, Chinese-owned Envision Energy and India-based Suzlon Wind Energy also have operations in Denmark. At its Global Innovation Center in Silkeborg, Envision Energy is developing a new off-shore turbine, whilst Suzlon Wind Energy’s global headquarters for blades are located in Aarhus.

While the globalisation has had a strong impact on the wind turbine manufacturers, the Danish market continues to play a key role for the supplier link. Half of the, little more than 100 wind power companies that contributed to the mapping of the Danish wind industry, which forms the basis of this report, generate a maximum of 25% of their wind power-related revenue from sales to wind turbine manufacturers or suppliers located outside Denmark. As such, many of the suppliers primarily feel an indirect effect of globalisation through their relations with key customers.
One of the ways in which suppliers feel the globalisation of wind turbine production is that they do not necessarily win the large orders from turbine manufacturers but have to settle for production of 0-series, whilst subsequent mass production takes place abroad. In the words of one supplier:

You see, we currently pack these assembly kits in a 40-foot rack, put them in a 40-foot container, throw them on a truck […] The kit is then assembled in China, put in a 40-foot container and shipped back.

However, there is a tendency for wind power-related revenue deriving from export sales to rise in step with the company’s focus on wind power. Accordingly, the greater the proportion of its combined revenue a company generates from sales related to wind power, the greater the likelihood that a substantial proportion of the wind-related revenue will derive from sales to turbine manufacturers or suppliers located outside Denmark. For the small group of companies in the survey whose revenue derives exclusively from wind power sales, more than half of their revenue is generated from exports.
Revenue generated outside Denmark may still be generated from sales to companies such as Vestas, but in that case it would be to one of Vestas’ foreign sites. The global outlook for quite a few Danish suppliers – also relative to Danish turbine manufacturers – is described by a medium-sized component supplier:

> You see, our strategy is to have a presence where Vestas is in the region for the region. […] It’s not because it is cheaper for us to manufacture our products in China, so it’s exclusively a matter of logistics.
> […]
> Once we reach the stage when our operations in China are fully operational and perform well and we wish to expand further, we would most likely turn our attention to the USA, or perhaps Mexico.

Danish companies have had quite a consistent focus on wind power in recent years, so only a few companies have sharply increased or reduced their relative revenue from wind-related activities. However, this relatively stable pattern in corporate focus on wind power does not necessarily imply that the proportion of businesses generating a substantial part of their wind-related sales from foreign customers will remain at the same level going forward. The group of companies with no international sales and the group of companies that generate limited sales outside Denmark both include companies with operations abroad. It would be difficult not to interpret this as anything but an ambition to boost international sales.
For the companies with no international sales, the figures are almost too insignificant to warrant any interpretation, but nevertheless, two out of 13 companies, corresponding to 15%, with no international sales, indicate that they have sales activities abroad. However, among the slightly larger group of companies that generate less than 10% of their wind-related sales outside Denmark, almost half have foreign sales activities.

The international sales activities are centred not only on “well-known” customers in the Danish market. The Chinese manufacturers have become attractive for Danish suppliers. In the words of one Danish supplier, who has completed its first large order to a Chinese customer and has signed a contract with several other Chinese customers, about the internationalisation process:

So we started to look into this China business. Well, at the time, in 2005, there were 40 manufacturers in China, and looking at that number we thought […] you know, not all 40 manufacturers will survive.

[…] When I first came here […] in 2004. 95% of our customers were located within a 100 kilometre radius. Today, we have customers, as I’ve just said, in China and Korea and I also ship products to the USA […] the whole world is our playground now, right? I actually think that this is the key challenge that our industry is facing.

Even though quite a few Danish suppliers may start their globalisation process by following a key customer, such a relocation may also provide opportunities to become part of, for example, the blooming value chain of the Chinese turbine manufacturers. With respect to
relocating operations together with Danish customers, one Danish turbine manufacturer says that suppliers may be surprised to learn that the relations they have built in Denmark are not automatically transferred to non-Danish operations:

…the Danish suppliers often fail to grasp the new situation and understand the new setting. So when […] we relocate operations, when we start to regionalise activities around the world due to various political or financial requirements, Danish suppliers typically think that their existing relations will apply at the new location – but that is just not the case.

Although there are clear signs that the supplier link of the Danish wind industry is starting to become more global, there is still some way to go before the Danish wind industry as such can be described as truly global. National trade relations continue to play an important role, and these relations are often personal and localised.

Do foreign-controlled companies act more globally?
Foreign ownership of Danish-based companies in the wind industry extends beyond the wind turbine manufacturers.

More than one in four of the respondent wind power companies are either wholly or partly controlled by a non-Danish company. This proportion could be underestimated if Danish-controlled companies have had a greater incentive to participate in the survey than foreign-controlled companies.

This is a much greater share of foreign ownership than for the Danish private sector as a whole (according to Statistics Denmark and StatBank Denmark, only 1% of the companies are under foreign ownership). For the industry alone, foreign ownership stands at just under 3%. However, companies under foreign ownership account for a substantial part of employment (19%) and revenue (23%) in the private sector (Statistics Denmark, 2010). Foreign ownership of suppliers is not exclusively explained by international acquisitions of Danish wind power companies, such as when UK private equity fund Doughty Hanson took over LM Wind Power (then named LM Glasfiber) in 2001. There are also a large number of foreign-owned companies that have built their operations in Denmark from scratch.
In global terms, the foreign-controlled companies are larger than the Danish-controlled companies, but the bulk of their employees are located outside Denmark.

While 92% of the companies under foreign control have activities abroad, the corresponding figure for Danish-controlled businesses is 63%. The foreign-controlled companies have more different types of activities abroad than the Danish-controlled companies, and the foreign-controlled companies stand out especially when it comes to R&D activities abroad: 60% of the foreign-controlled companies have R&D activities abroad, whereas only 17% of the Danish-controlled companies do.

R&D activities are never the only activities pursued by an enterprise operating abroad. Typically, companies with R&D activities abroad also have production, sales, sourcing and service operations outside Denmark. Only one company has indicated that it has R&D activities abroad without also at least having production activities outside Denmark; in this case the company has both sales and R&D activities abroad. Even though, unfortunately, the survey does not disclose where the activities outside Denmark are located, including for example whether production and R&D activities are placed in the same country, the results indicate interdependence or a tendency to place the activities in the same location. In other words, R&D activities do not take place at a different location than production.
Most Danish as well as foreign companies indicate that access to relatively inexpensive labour is a factor of importance when determining the location of new production activities (see Table 2). Customer proximity is the second-most important factor. However, customer proximity is emphasised by several companies when it comes to the location of service activities. Also in this regard, Danish and foreign-controlled companies agree on the prioritisation of important factors.

When it comes to the location of R&D activities, there is a difference between Danish and foreign-controlled companies. More Danish-controlled companies point to customer proximity as a key factor. Conversely, among foreign-controlled companies access to specialised labour is mentioned by most as a factor of importance for the location of R&D activities. More than half of the foreign-controlled companies also point to proximity to specialised knowledge environments/test facilities as a factor of importance for the location of R&D activities. Non-Danish prioritisation of these factors may explain why a company such as China-based Envision Energy, as mentioned above, has placed its R&D department in Silkeborg, Denmark.

However, the percentage differences between Danish and foreign-controlled companies should be interpreted with some caution due to the limited number of respondents. (Table 2 only covers companies which have responded “Yes” or “Don’t know” to the question of whether they plan to expand their production, service or development activities, respectively, within the next three years.)

**Table 1:** Activities abroad, broken down by ownership control of the company (N=101)
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</tr>
<tr>
<td></td>
<td>(N=50)</td>
<td>(N=20)</td>
<td>(N=58)</td>
</tr>
<tr>
<td>Access to specialised labour</td>
<td>44.00%</td>
<td>30.00%</td>
<td>36.21%</td>
</tr>
<tr>
<td>Access to relatively inexpensive labour</td>
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<td>55.00%</td>
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<td>40.00%</td>
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<td>45.00%</td>
<td><strong>67.24%</strong></td>
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<tr>
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<td>30.00%</td>
<td>15.52%</td>
</tr>
<tr>
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<td>8.62%</td>
</tr>
<tr>
<td>Access to well-developed infrastructure</td>
<td>28.00%</td>
<td>35.00%</td>
<td>13.79%</td>
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<tr>
<td>Local legislation</td>
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<td>40.00%</td>
<td>17.24%</td>
</tr>
<tr>
<td>Other</td>
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<td>10.34%</td>
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<tr>
<td>Don’t know</td>
<td>12.00%</td>
<td>30.00%</td>
<td>8.62%</td>
</tr>
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</table>

Table 2: Factors of importance to the location of new production, service or development activities

Foreign-controlled companies differ from Danish-controlled companies by having less wage-intensive production: there are twice as many foreign-controlled as there are Danish-controlled companies with a wage component of less than 10% of the combined production costs.
However, as can be seen from Table 2, the Danish-controlled suppliers remain focused on the wage component. Some have already invested so comprehensively in automation that payroll costs only represent a fraction of the accumulated component costs:

Our wage component for the products we manufacture domestically for Vestas and Siemens in Europe. […] Here, the wage component is about 6%. […] First it is the raw material, then the processing, so we’re talking about extremely expensive machinery here. In our manufacturing we use very, very expensive machines. So if the machine costs 10 or 20 million kroner, it doesn’t matter very much whether the person handling it is paid 50 kroner or 200 kroner an hour.

Another supplier emphasises that increased automation is not only a way to reduce the wage component and thereby ensure that Danish manufacturing can remain competitive. Automation is also a means of ensuring consistent quality in a global production:

If we are to stand any chance at all of retaining production in Denmark, we need to address the issue differently and more cleverly – otherwise we won’t succeed. We need to generate more value than we do today. We need to raise our productivity, by quite a lot in fact, and we also need to improve production quality. The means of achieving this is to use robots and state-of-the-art technology as this is one of the few ways of ensuring consistency. […] companies like Vestas, which has […] I believe it is about 40 different production units worldwide. If you have global production operations, automation and the use of robot technology will also provide consistent global production.
In the experience of a Danish wind turbine manufacturer, the effective, consistent, stable and price-competitive mass production which can be documented by way of internationally recognised process and production optimisation tools such as Lean, Six Sigma and PPAP (Production Part Approval Process), may represent a challenge, especially to small Danish suppliers, whilst foreign suppliers are often better equipped – sometimes even better than the customer:

Six Sigma … many [foreign] suppliers […] Well, they are way ahead of us in this area. Many of the Danish players on the other hand, can’t keep up […] In other words, many players […] face a very steep learning curve when addressing this task.

Quite a few of the suppliers acknowledge that they are faced with a challenge in respect of more effective processes:

We are much too wage-intensive. We have a lot of skills and we work in niche areas. I only have one goal that I constantly aim for now, and that is the reason why we have invested in welding robots, new cutting machinery […] So it all comes down to the wage component, it simply must be reduced! – otherwise we’ll never make any money […] We simply need to work on our processes. We have a lot of catching up to do.

In addition to the fact that the foreign-controlled companies apparently focus more on payroll costs than the Danish-controlled companies, the survey also shows that the foreign-controlled companies are more inclined to exchange knowledge about wind power with universities. While half of the foreign-controlled companies state that they collaborate with universities, this only applies to one-third of the Danish-controlled companies. The foreign-controlled companies cooperate with both Danish and non-Danish universities, whereas the Danish-controlled companies primarily cooperate with Danish universities. The Danish universities most frequently taking part in such collaboration are the Technical University of Denmark, of which Risø is now a part, and Aalborg University. No particular foreign universities are highlighted, and it is worth noting that the respondents refer to universities they work with in Europe, the USA and China.
In other words, the globalisation of the wind industry described in chapter 1 is also reflected in the foreign-controlled companies’ global collaboration patterns. This, in turn, demonstrates that new knowledge about wind power is developed worldwide and not only in Denmark. The fact that the foreign-controlled companies are more focused on knowledge generated outside Denmark may not come as a surprise. However, the Danish-controlled companies may face a challenge if they retain the old habits of exclusively seeking knowledge developed domestically and rooted in the period when Denmark’s position as the cradle of the latest knowledge about wind power was more uncontested than it is now.

Still, this should not be interpreted to mean that Denmark no longer has comprehensive wind power skills that attract industry players to the country. One supplier underlines the importance of Denmark’s extensive wind power experience:

Obviously, there is a reason why Chinese companies establish a R&D department here in Denmark – why do you think that is? […] I have to say that many of the wind turbine manufacturers I meet when I travel around the world simply do not give the attention to detail that Vestas emphasises. They simply don’t. Naturally, they cannot just accumulate the experience that we have built over the past 30 years. They will learn a lot quicker, but not just overnight. That’s just how it is.

Even though the wind turbine manufacturers are able to identify weaknesses with the Danish suppliers, one turbine manufacturer highlights the value of the technical insight that the Danish suppliers possess:
Of course, there is the fact that Denmark’s group of suppliers represents the value it does [...] we truly benefit from the fact that, broadly speaking, they know more about our field than they do in many other places. Naturally, there are many skilled suppliers out there these days, but the fact remains that we have people in Denmark who simply have much better skills.

One supplier said that the proliferation of wind power in Denmark continues to make the country attractive to foreign companies.

We are a unique little prototype society where we’re able to come up with solutions that others can only watch. If we play our cards right, I believe that we can export this knowledge because nowhere else in the world do they have a penetration rate as high as in Denmark.

What makes the Danish market for wind-related products and services attractive to foreign companies, and access to customers located in Denmark a likely key factor behind foreign investments in the wind industry, is probably the fact that most of the foreign-controlled companies in Denmark – as well as the Danish-controlled companies – generate the bulk of their revenue from sales in Denmark. Although a much greater proportion of Danish-controlled than foreign-controlled companies exclusively generate wind-related sales in Denmark (15% vs. 4%), a look at for example the proportion of companies generating a maximum of 25% of their wind-related revenue abroad, reveals only a small difference: 53% of the Danish-controlled companies generate up to 25% of the wind revenue abroad, whilst the same is true for 51% of the foreign-controlled companies. However, we cannot rule out a certain bias in the responses or that foreign-controlled companies with less focus on the Danish market to a greater extent have opted not to participate in the survey, than companies focusing strongly on the Danish market.

Figure 11: Share of wind-related sales to non-Danish countries, broken down by ownership control of the company (N=100)
The answer to the question of whether foreign-controlled wind power companies in Denmark generally operate more globally than their Danish counterparts is “yes”. At the same time, however, the results of the survey show that the Danish market is pivotal to Danish as well as to foreign-controlled companies. Although there are also signs of increasing globalisation in the supplier segment of the wind industry, the Danish wind industry remains strongly anchored in its domestic foundations.

From the point of view of the turbine manufacturers, however, the wind industry’s value chain remains increasingly global, and this is expected to affect the Danish suppliers. In the following, we will describe more closely the principal drivers behind the developments of the global wind industry.
3. Development drivers

Consultants and experts have many different views on what drives developments in the wind industry and influences the organisational evolution of the value chain. In the following, we will consider demand conditions, globalisation and technological advances as the principal development drivers.

Movements in global demand for energy

The mounting energy needs of the BRIC countries are key to understanding the driving force behind developments in the global and, by extension, the Danish wind industry. These developments involve direct and derived effects. The direct effects are ascribable to an ever-growing need for a portfolio of energy types, partly to complement the conventional sources of energy, partly to create a more balanced, and thus less vulnerable, supply of energy distributed on multiple sources of energy. Total energy infrastructure investments, in addition to oil and gas, are estimated to run to USD 18,000 billion over the next 25 years (IEA, 2011b). These developments have one near-term and two long-term derived effects for wind power: in the near term greater demand has resulted in a sharp increase in the price of conventional sources of energy (with the exception of nuclear power). The price of crude oil, for example, is expected to rise by about 30% during the period 2009-2013. In 2011, the average price of a barrel of crude oil was USD 94. In February 2012, the price was USD 99 per barrel, and the average price for 2012 is expected to be just over USD 100 (EIA, 2012). The need to supplement non-renewable sources of energy is rooted not only in the price, however. Indirectly, this price development means that the world’s reserve stocks are being depleted and there is a growing need for politicians to ensure access to complementary alternative sources of energy.

There are also geo-political consequences of these trends: the growing demand means that non-renewable sources of energy are being depleted, and that in turn entails a mounting need for, and political will to ensure, access to other sources of energy such as wind power. In addition, in recent years we have witnessed intensifying research into utilising electricity for broader purposes, for example in the transport sector. Even though there is some disagreement over the size of the oil, coal and gas reserves and how far into the future they will actually last, there is no doubt that the reserves are limited. Apparently, the increase in oil extraction volumes has become stagnant, and therefore a number of people believe that the world has passed to so-called oil peak point, after which the production rate will fall, although others believe that this will not occur for another ten years (EIA, 2012).

The other trend is that the price of green energy develops favourably relative to conventional sources of energy, and in the USA, for example, this triggers growing interest in wind power among key investors such as energy producers and power grid companies (Salerno & Shahan, 2010). One way of calculating this trend is to use the calculation method called “levelized CoE”, which includes factors such as capital investments, carbon taxes, operating and maintenance costs (EWEA, 2012). This method shows that electricity generated from nuclear power is by far the most expensive source of electricity, whilst gas is cheaper than
both wind and coal. A projection until 2020 shows that onshore and offshore wind power will gradually become the cheapest alternatives. When a risk premium is added relative to the unpredictability of raw material costs, the benefit of wind power accelerates even faster. Not only wind power stakeholder groups point to high capital requirements for investing in nuclear power. For a more objective source, see e.g. The Economist, 10 March 2012, "The Dream that Failed."

Figure 12: Levelized costs of electricity

*) Includes CO2 and capital investments over the life of the plant

Figure 12: “Levelized CoE” – the costs have been levelized so that capital expenditure (investments) and operating costs are included in the comparison of total costs
(Source: EWEA, 2012)

Even though the energy costs for non-renewable sources of energy such as gas and coal are still lower than or on a level with wind power, the picture becomes less distorted in a 2030 projection, which includes expected price increases of gas, in particular. It is also important to bear in mind that average wind power costs continue to fall in step with advances of turbine technology towards more efficient turbines, but not least in relation to facility exploitation. The other aspect is that average prices of the turbine itself have declined by 22% over the past three years, largely due to the excess capacity that arose in the wake of the financial crisis and the resulting slump in demand and postponement of scheduled projects. This has also helped generate productivity increases, and the trend is very well illustrated by the following quote by a manufacturer interviewed in connection with the preparation of this report:
I was part of a project ... to improve our assembly of what was then our large 450 kilowatt turbine, and back then we were happy when we were able to scale the job down to 850 man hours. Today, we assemble a 2.3 megawatt turbine using 250 man hours. That is an output almost five times higher, and the number of man hours has been reduced to about one-third. So we end up with ... a factor of more than 3. We get a productivity improvement factor of more than 15 per megawatt ... I believe that the record lead time for a turbine is about 17 calendar hours.

Given the strong price competition for turbines and the appearance of new manufacturers, this trend is set to accelerate, especially for turbines of 2 to 3 MW (Berger, 2011, Interviews). The last significant factor driving demand for wind power is that, from a supply viewpoint, it is important to have a portfolio of different technologies that complement each other to ensure reliability of supply and reduce reliance on external suppliers of energy. A total of more than USD 5,000 billion is expected to be invested in the power sector worldwide over the next 25 years, and wind power is set to absorb a large part of this amount. According to World Energy Outlook, a projection of developments in alternative energy source capacity would look as follows: (Figure 13)

![Figure 13: Sustainable energy mix in tomorrow's power production](Source: World Energy Outlook 2010)

Expectations of future developments create dynamics among investors and companies, leading to ownership consolidation in several links of the value chain. In recent years, the wind turbine manufacturers have witnessed a major consolidation process, especially in Denmark but also in other countries. The power companies have become increasingly global and are now dominant owners of wind power plants. One example is Spain-based Iberdrola, which operates in more than 20 countries, both directly and through joint ventures with other companies (BTM, 2011b). Vattenfall and DONG are other examples of
regional players specialising in the offshore market. DONG is also a good example of another consequence of the consolidation process – an upstream or downstream integration with other players of the value chain with a view to identifying new ways of building market value and control. DONG’s acquisition of A2SEA is an example of how DONG has made acquisitions with a view to developing special skills in foundations and installation for the offshore market (DONG, 2012).

A third factor is the fear of the consequences of climate change caused by increased carbon emissions from conventional sources of energy. This factor also affects demand for wind power and it has political consequences in the form of national and international energy policies, framework conditions and agreements (EU directives for example) seeking to incorporate environmental factors and promote the proliferation of renewable energy sources. For example, the German government’s decision to abandon nuclear power and focus more on sustainable energy sources is also attributable to this factor. As a result, wind power plants are being installed in a growing number of countries, and several countries are moving from the experimental stage to a more dedicated stage measured in terms of installed MW (BTM, 2011b).

Investments are also channelled to the development of other renewable sources of energy such as solar power and wave energy. Hydropower remains an important sustainable source of energy, but the utilisation rate is close to 100%. So far, no other renewable sources of energy have been found to have the same potential as wind power (IEA, 2011a). Consequently, there is every indication that wind power as a technology will dominate the expansion of renewable energy in the coming years in Europe and the rest of the world.

**Semi-globalised markets create new strategic opportunities**

Recent years’ market growth has been characterised by the fact that a substantial proportion of the expansion has taken place in “emerging” markets outside Europe and that the differences in the composition of demand across markets are becoming increasingly apparent as China and India have grown into major markets. The largest part of the market increase over the next 8-10 years is expected to be centred on 12 markets in the USA/South America, Asia/Pacific and Europe (according to Roland Berger Consulting, the 12 countries are: Australia, Brazil, Canada, the UK, France, India, Italy, China, Spain, South Africa, Germany and the USA).

At the same time, the number of countries with more than 500 MW of installed capacity is expected to grow from 13 in 2010 to more than 25 by 2020 (Roland Berger, 2011). Increasing globalisation does not imply a more level playing field in terms of competition and market conditions or that localisation benefits are eliminated, economies of scale and scope being the critical factors. Economies of scale and scope refer to the fact that the variable scale and capacity investments may be distributed across a number of activities and thus be utilised more effectively.

One way of illustrating this new and “semi-globalised” market situation is as shown in Figure 14 below. As suggested by the figure, the global market for wind turbines may be regarded as three partly overlapping regional markets, each of which is driven by special
competition dynamics and strategic agendas. In Europe, politicians focus extensively on the offshore market. This trend is monitored closely by many industry players who develop and align their operations relative to these expectations, and this in a market driven by consolidation. In Asia, capacity growth still occurs in the small turbine segment, there has been a substantial increase in the number of new players, and price competition in particular is severe. In the USA, focus is on the medium-sized and large turbines. As in Europe, the US market is consolidating, but attention is centring on South America as a potential growth market. Furthermore, players to some degree overlap these markets, so they also span across regions in their competitive efforts, helping to tie them together for the global players (Porter, 1986). For example, success for or resources in one market region could improve the opportunities in another market area.

Even though some factors of our survey indicate that turbine technology heads for a more simple and standardised design and that scale economies will become increasingly important in a number of processes, other value chain activities to a large and growing extent require these companies to adapt to local market and operating conditions. Even given a large correlation across market areas, there are clear divisions and market arenas dominated by certain value chains and conditions, and in the long term they are likely to create space for establishing more standards and variants.
Measured in terms of MW size, three global segments are currently developing: The Chinese and Indian markets still consist of small turbines of less than 1.5 MW. This segment is to a large extent supplied by local manufacturers such as Suzlon. The mid-segment (1.5 to 2.5 MW), which accommodates the bulk of the demand, is currently covered by Chinese manufacturers. The large turbines (larger than 2.5 MW) are dominated by European manufacturers, especially Vestas, Siemens and Enercon. The overlap between markets demanding multi-MW turbines and markets which have an offshore segment is no coincidence. However, the market segments are not in any way reservations fenced in by access barriers and protected against outside competition. Some European manufacturers, including Gamesa, try to compete in the small-turbine market, and especially in the mid-size market segment competition is fierce among European, Asian and US manufacturers. US and European manufacturers have thus commenced operations in China over the past 5-10 years in order to develop and market turbines adapted to local market conditions, but these players are under huge pressure from local Chinese manufacturers, who from 2005 to 2010 took over the bulk of the Chinese market (RolandBerger, 2011). A similar trend may well develop in the offshore segment as illustrated by Goldwind and Sinovel developing new large turbines for offshore use and Envision’s development activities in Denmark. Korean manufacturer Samsung is also testing a 7 MW offshore turbine in Scotland, and many people are regarding this as conclusive evidence that Samsung is seriously considering becoming a wind turbine manufacturer. In other business segments, Samsung has proven itself to be highly competitive.
As competition intensifies in China, more Chinese manufacturers of wind turbines and components will seek to develop products and services for the European market, intensifying competition among the manufacturers. This trend will have two opposing effects for supplier business conditions. First of all, increased complexity, unpredictability and requirements for speed-to-market will most likely make a number of the manufacturers reconsider the strategy of maintaining a high degree of in-house production of components, or at least considering supplementing in-house capacity with external shipments. This applies especially to manufacturers such as Vestas, Enercon and Mitsubishi, all of which currently source all or nearly all critical components in-house. This will expand the market for the suppliers. One supplier describes the situation as follows:

...in this regard we see that certain players in our industry have another, should we say, strategy, and the most distinct player is in fact GE, right? GE, you know, they are a supply chain company. ... They make their own design or procure it elsewhere, improve it beyond recognition, provide the underlying supply chain, they may contract with the companies supplying the raw materials and then they tell a company in Brazil or some business in China or whatever...: “There you go, here are the moulds and the equipment – now you can start manufacturing!”

Secondly, the competitive pressure will motivate suppliers from a number of countries to consider or decide to commence operations in new markets, further intensifying competition among the suppliers. However, it is very difficult to render a complete and unambiguous picture of the suppliers’ market situation due to very large differences in the degree of standardisation of components and the global competitive pressure across component and system shipments. The figure below shows examples of the degree of global competition for critical components. The position in the figure is determined by the extent to which the total number of leading suppliers within the given component supplies customers locally, regionally or globally (BTM, 2011a; MAKEconsulting, 2010). It should be emphasised that the figures are rough estimates, and the position on the scale should be viewed as an indication rather than an exact specification of the average supplier position.
This type of market developments where there is either a movement towards uniform, standardised supply and demand compositions or where requirements for local market adaptation lead to product variants that can only be sold within a confined market area are called semi-global (Ghemawat, 2010). Many factors in the wind industry seem to indicate that scale economies increasingly gain importance relative to adaptation benefits. Large series create learning advantages, movements towards standardisation and recycling of solutions and create learning opportunities, and it would seem that this scaling or industrialisation will ultimately create the market conditions that will be able to realise a cost parity for wind energy relative to coal and the other conventional sources of energy. To a greater or lesser extent, it is the same market factors that affect production and demand. However, they are also very different in terms of composition. Political conditions, geographical and climate differences, framework conditions, stakeholders, skills and other aspects of the factor endowment will continue to create and maintain substantial differences. We are probably not heading for a global market dominated by standardised solutions. On the other hand, we are likely to witness – especially on the supplier side – intensifying global competition.

The complex organisation of value chains that follows from semi-globalisation is also reflected in collaboration and competition conditions for the players in the value chain. In the future, the market for wind power will also be dominated by regional players with localisation benefits, but these players are coming under pressure from a few global bridge builders in several layers of the value chain. Figure 17 seeks to group the manufacturers into six strategic groups.
Manufacturers such as Siemens and Vestas, but also global and regional buyers of wind turbines such as Iberdrola and large suppliers such as ABB (generators), Hansen Transmissions (gear boxes) and LM Wind Power (blades) create strategic competitive advantages by maintaining a presence in several regions. Other suppliers like Bladt foundations and substations so far have no actual activities outside Europe. On the other hand, only very few players – with the exception of the Chinese manufactures and suppliers – can survive if they maintain a presence in only one region. They contribute to complicating the strategic picture, resulting in semi-restricted market areas with independent market dynamics and inter-regional spillover.
Players in the wind industry operating across these semi-global markets will thus not only have opportunities to capitalise on location and standardisation benefits, they will also enjoy economies of arbitrage: the ability to effectively utilise correlations in market differences to the optimum extent (Ghemawat, 2007). In tomorrow’s global wind industry, the local, regional and global players will base their strategic competitive strength on a combination of these three principles, and especially the global players will benefit from an ability to act across market differences.

**Figure 18: Competitive parameters in the wind industry**

Most of the adaptation and aggregation advantages (or lack thereof) referred to in Figure 18 have already been discussed elsewhere in this report and will not be reiterated here. Worth mentioning about the arbitration advantages is that there are currently major differences in terms of MW prices across the regions, that the differences between supplier production skills and quality management in Europe and for example in China and India are smaller than many Danish suppliers imagine, and that there are huge differences in terms of how manufacturer strategies unfold in relation to conquering market share and setting up operations. It is also important to emphasise that, even though Denmark remains a global leader in certain areas – for example aerolastic design of rotor blades – important research and knowledge hubs related to wind power have surfaced in Germany and the USA, and more are underway in China and other countries. This is reflected in, especially, the foreign-controlled companies’ collaborations with foreign universities described in chapter 2.

In addition, knowledge about organisation and management of global business activities,
including supply chain management or global innovation and tech transfer (how technologies are transferred across geographical or cultural gaps), have become an increasingly important skill for supplier enterprises. A number of players believe that optimising organisational and management processes across value chain players may reduce overall production cost by about 10-15%, which is more than the expectations of CoE savings through technological breakthroughs on the component side (RolandBerger, 2011). This need matches the replies given by suppliers to the Danish wind turbine industry in a recent survey of their training requirements. In the survey, nearly half of the respondent companies replied that they need to develop their market and business skills (Kristiansen, Lindgren, & Johansen, 2012).

**Strong growth in offshore installations**

In recent years, offshore activities have come to represent a growing proportion of annual MW growth. By 2015, an estimated 10% (15% by 2020) of the global capacity growth is expected to be from offshore facilities (RolandBerger, 2011). The offshore segment is growing, especially in Europe, right now and is believed by many to be the “new” area for European wind turbine manufacturers. So far, this will not lead to migration of jobs from the affluent part of Europe to low-wage economies since many of the activities undertaken are capital investments. In 2010, offshore projects accounted for 3.6% of total installations worldwide, whilst they represented nearly 10% of all installations in Europe (EWEA, 2011b). Until now, the establishment of offshore capacity has centred on a few countries in Europe: the UK, Denmark, Belgium and Germany, but in the years ahead offshore activities will spread to far more countries in Europe, and it is estimated that 18 European countries will have offshore wind farms by 2020. The growth rate of demand for offshore MW exceeds the onshore growth rate, but in absolute terms the annual capacity growth remains modest. Denmark accounts for just over 23% of the total capacity in the area, whilst the UK (capacity of more than 1,800 MW) controls half of the offshore capacity. Most of the companies that participated in the survey underlying this report – 63% – actively participate or have previously participated as direct or indirect suppliers to offshore projects in the UK, Denmark or Germany.
A number of large projects are being planned in Europe, and Germany and the UK in particular are expected to increase their investments in the area within the next five years. A count performed in 2011 identified 141 GW – or 141,000 MW – that was either under construction or at the planning stage – primarily in the North Sea. Overall, this means that Europe is expected to witness a six-fold increase in offshore capacity in the years ahead. In this regard, it is important to note that the price of offshore MW is more than double the price of onshore MW and that installation costs account for between 50% and 60% of the MW price. Also, the offshore value chain involves a number of new players in the fields of safety, logistics, service, cabling, ocean floor anchoring etc. Similarly, the activities indirectly related to establishing and operating activities involve a number of assignments in the form of projecting, capital procurement, various measurement and calculation tasks, training and many other assignments. At the same time, advances in the area create pressure to identify suitable locations in deeper waters and under increasingly difficult sub-surface conditions. This in turn leads to new challenges, offering space for new players and innovative solutions. In a prudent estimate, European investments in offshore capacity in the next few years will represent a market value of between EUR 5 and EUR 10 billion, and according to calculations, the investments will have created 300,000 new jobs in Europe alone by 2030 (many of them high skill jobs) and created new export opportunities. For the same reason, wind power in general and the offshore segment in particular is regarded as a strategic research area at EU level, and the coming EU budget has earmarked DKK 200 billion for wind power research and development (From, 2011).
In addition to requiring large capital investments, the offshore market differs from onshore in that it demands large turbine types. The average size of onshore wind turbines has stopped growing. The reason is, in particular, that Chinese investors largely focus on 1.5 MW turbines, which represent a thoroughly tested design. Another reason is that the population is becoming increasingly opposed to very large land-based turbines which are highly visible in the landscape. Conversely, offshore facility customers demand large turbines for a number of reasons (EWEA, 2011b). It is relatively less cost-intensive to establish and service wind power capacity offshore if the wind farm consists of few instead of many turbines (BTM, 2011b).

However, opportunities for developing the European offshore market are also under pressure from other factors. As mentioned previously, offshore facilities are still very expensive from a CoE perspective, and providers of wind power solutions are therefore being challenged by sources of energy such as nuclear power – despite the greater number of job creation opportunities. In the Netherlands, a decision was recently made to postpone investments in a scheduled offshore facility and instead invest the funds in the expansion of a nuclear power plant (Willum, 2011). In this way, the global economic crisis poses another and more strategic threat to kick-starting the European offshore market: if the European market does not have sufficient volume, the regional players will fail to develop the learning benefits and economies of scale necessary to reduce offshore costs. Consequently, the development opportunities may be lost and, due to focus on obtaining the cheapest solution, investments may be channelled to non-European players, who in turn will accumulate new skills. The only market truly driving current developments is the UK.

Technological advances and challenges

Another key framework condition is the technological advances and the resulting challenges. Basically, the technological challenge lies in optimising the energy costs in order to reduce the overall CoE. Developing more efficient and reliable units that are also less cost-intensive is paramount in this context but, increasingly, it is also about being able to minimise establishment and service costs, the ability to make an effective grid connection and maximise the utilisation of wind sites. The result for the value chain players is more complex and multifarious requirements. When load capacity and reliability relative to individual dominant turbine designs can be identified, this broader focus may open up for new turbine designs in the market. In the following, we will discuss aspects relating to the technological advances and how these challenges contribute to affecting, and in some cases reconfiguring, the value chain: turbine designs and power grid connection.

Turbine designs

A wind turbine is a complex system composed of a number of sub-systems and components whose functional capacity is interdependent. This means that if the dimensions of a sub-system is adjusted, for example if the weight of the blades and the hub is increased, this will affect the dimensioning of all other turbine systems (tower height and anchoring, gear steel quality, brake system etc.). This complicates coordination efforts and, by extension, the development of wind turbines, and it means that only very few critical system suppliers can play a proactive role in developing turbine designs. This issue has also contributed to creating a so-called dominant design, a standard which the vast majority of the industry
players accept as the golden standard. It also contributes to design advances through gradual adjustments which over time develop into market standards and best practice for all players (Anderson & Tushman, 1990).

In this established design, the wind turbine can be divided into six large sub-systems, the combination of which account for approximately 77% of the total price of a wind turbine. A residual group makes up the rest. These systems are shown in the table below along with the key development challenges and cost potential (potential savings through improved design).
## Component Development

<table>
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<tr>
<th>Component</th>
<th>Development potential</th>
<th>Expected savings from more cost-efficient design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blades</td>
<td>Weight/length ratio, Intelligent load shedding, Alternative building materials with relevant properties</td>
<td>small, medium, rising, large</td>
</tr>
<tr>
<td>Gear</td>
<td>Weight-to-torque ratio, Inner design and lubrication of gears, Vibration dampening</td>
<td></td>
</tr>
<tr>
<td>Generator and converter</td>
<td>Better exploitation of wind energy – speed changes and small wind speeds, Development of direct drive technology (it is debatable whether direct-drive technology is part of the dominant design or a technological breakthrough), New ways of integrating the turbine in the grid</td>
<td></td>
</tr>
<tr>
<td>Towers</td>
<td>New materials and material hybrids, New structural designs for higher structures that can also be transported</td>
<td></td>
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<tr>
<td>Pitch and ball bearings</td>
<td>New materials and lubrication techniques</td>
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<tr>
<td>Electronic control systems</td>
<td>New intelligent systems to cope with load and reduce wear and damage</td>
<td></td>
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<tr>
<td>Other nacelle components (e.g., moulded or welded)</td>
<td>..</td>
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<td>Other</td>
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**Table 3: Development potential and associated expected savings on principal components and systems** (Sources: MAKEconsulting, 2010; RolandBerger, 2011)
The development of the dominant design continues in the form of larger turbines with a higher output capacity. EWEA, the European Wind Energy Association, has teamed up with a large group of experts to seek to extrapolate the development of a new type of turbine for offshore use. This turbine is expected to have a capacity of 20 MW. Such a turbine is projected to have a tower that is 150 metres high and a rotor diameter of 252 metres (EWEA, 2011a). By way of comparison, the prototype of Siemens’ 6 MW installed at the Høvsøre test station in Denmark in the summer of 2011 has a rotor diameter of 120 metres.

The drastic increases in wind turbine sizes involve large technological challenges. The weight of the turbines increases by a larger factor than the length due to the so-called “square-cube-law”. Therefore, it will require major design improvements to get a larger turbine to generate so much more power that it will be feasible for it to not only become e.g. four times larger but also eight times heavier.

Although some inertia has arisen with respect to wind turbine design, something would indicate that the turbine design can be changed because of the new and broader requirements to enhance efficiency and/or reduce operating and installation costs. An example of such a breakthrough is the direct-drive technology applied by Enercon for some years now, but which is also being taken over by other large manufacturers such as Siemens, Goldwind and GE Wind. The Direct drive design links the wind turbine’s axis directly to a generator. The energy is thus not transmitted via a gear box. Because the generator is placed in the nacelle, the turbine has a much larger topload, which increases manufacturing and building costs. On the other hand, the additional weight from adding a generator in the nacelle are counterbalanced as the gearbox can be left out. The costs of the gearbox (which is the size of a living room) counterbalance the increased weight from the generator some extent and in addition service costs are reduced as there are fewer mechanical parts to attend to. Furthermore, Siemens has successfully developed a direct-drive concept, which is used for example in the new 6 MW turbine mentioned above, dedicated for offshore use and with a lower mass per MW than the corresponding gearbox model. So far, the problem of the direct-drive technology has been two-sided: even though Enercon has manufactured direct-drive turbines for many years, the concept is not considered to be as thoroughly tested as the traditional gearbox model. The other issue relates to the use of permanent magnets, which is a type of special super magnet manufactured from the metal neodymium, which is relatively rare and therefore expensive. In addition, there is the technological challenge relating to the super magnets that they require more advanced cooling systems (Li & Chen, 2008).

Other break-out attempts also seek to divert from the dominant design. One example of an attempt to break from the conventional turbine design is Chinese-owned Envision, which has a R&D office in Silkeborg, Denmark. Envision’s ambition is to develop a simplified offshore turbine designed to operate with two, rather than three, blades and based on external production. The company has production capacity in China, but in line with the large Chinese manufacturers it expects to outsource the production of the bulk of its components to suppliers. Envision’s offshore turbine is expected to be ready testing in the Østerild area during 2012.
Many players of the wind turbine industry have expressed scepticism with respect to these attempts to break with the existing design. In particular, there is the challenge relating to ensuring reliability. In this regard, the maturing and comprehensive testing of new components have proven critical to live up to the extreme requirements for reliability emphasised by the sceptics in the wind turbine industry. One of the seasoned industry players, and one of the world’s leading scientists in the area, is not quite as sceptic:

... you know, we have a development system which is far more efficient and know-how that is also much more effective than others do. What I would fear could be happening in China right now is that they are feeling less bound by tradition. That they dare try something new. One surely dares to try something new, or what? And the players do tend to try new designs without very many obstacles – a bit like we did it in Denmark 20 years ago. I somehow fear that they have actually found that model.

Integration of wind power in the grid
Electricity is produced and used at the same time and cannot be stored in large volumes. Also, it is important that the voltage in the grid is fairly constant; too high grid voltage can lead to overloads and short circuits, whilst too low voltage may cause brownouts. Consequently, it is difficult to harness the wind to the optimum extent. For example, the wind often blows at night when power consumption is relatively low. As a result, there is some disagreement as to how large a proportion of the Danish wind energy is actually integrated in the grid, thereby replacing fossil fuels, to the benefit of value growth in Denmark, and how much of it is sold in the European spot market or via Nordpool (Cepos, 2009; Ceesa, 2009). Independently of this discussion, there is a recognised need for promoting the integration of wind power in the existing grids. There seems to be two overall development tracks that will both affect the wind industry. The first track involves the creating of new possibilities of storing wind power. One of the frequently discussed solutions is to integrate a swarm of batteries in electric vehicles on the grid and thereby create a storage possibility at night. If these vehicles were hooked up to an intelligent grid, they could function as a storage unit to act as buffers during periods with no wind, as it would be possible to de-charge the batteries in the vehicles and re-direct the power to the grid. In this way, the wind power could be stabilised, replacing a conventional power plant. It is estimated that approximately 50,000 Danish electric vehicles would generate sufficient critical mass to contribute to solving the problem of power storage (Andersen, Mathews, & Rask, 2009).

In the past few years, a number of projects have been underway in this regard, including power company DONG, which has entered a strategic collaboration with Better Place, a provider of electric vehicle systems. If the system works according to intentions, a large hurdle will have been overcome with respect to continuing the proliferation of wind power. However, the development of this solution involves a large number of challenges, including the establishment of an intelligent power grid. Furthermore, the number of electric vehicles in 2012 will probably not exceed 3,000 cars (interview with Better Place, 2011).

The second development track should lead to greater integration of the European power grid so that existing structural market errors can be eliminated. This solution has been extensively covered by the media and European environment politicians, but first of all it requires large-scale investments and must also be coordinated with a number of national interests.
So far, problems with respect to integrating wind power in the grid have been encountered mainly by Denmark and Germany, and similar attempts to identify cross-border solutions involving national interests have proven to be very difficult. The new problems also have direct consequences for the specification of the electronic turbine control. Originally, the turbines were disconnected from the grid in case of critical situations in relation to delivering power. Today, the turbines are increasingly designed to be able to respond to voltage fluctuations and intelligently to vary their input. This places greater demands on the electronic controls that enable the turbine to respond more quickly. The ability to control the wind turbine’s grid connection is a key parameter in terms of increasing input from the turbine and thus reducing the average price per KWh.

To some extent, the above factors define the framework conditions for the players of the Danish wind industry. In the following chapter, we will discuss the strategic challenges facing the market players. We focus especially on suppliers in the wind sector as we believe that some relationships between suppliers and manufacturers remain crucial for the industry dynamics. However, a number of the challenges we identify are also relevant to players in a broader selection of the wind industry value chain.
4. Strategic challenges facing Danish players in the wind industry

Generally speaking, the challenges facing the players of the wind industry derive from the industry’s ongoing evolution and maturation process. This means an ongoing change in competitive competition and collaboration parameters as the industry matures. The development of new generations of wind turbines used to be the most critical innovation activity, and supplier development skills were pivotal for advances in wind turbine designs. New requirements have emerged in recent years, changing these activities: requirements for quality management, “time to market” servicing and the ability to form part of and relocate along with the manufacturers’ global production activities. Collaboration in these areas is also undergoing change: the coordination of the supply task has become too complex to handle exclusively through informal relations between suppliers and manufacturers. The ongoing streamlining of logistics systems has led to the emergence of new players specializing in connecting the global value chains.

Particularly, the suppliers experience these changes as a mounting transitional pressure to transform the business model. The actual transformation process pressure is rendered more difficult by the fact that many suppliers have a long-standing track record and extensive industry experience. They have core skills in developing components and to some extent are have a contrasting view expected to be able to address the changing market practices by pursuing business as usual. In some areas, these factors combine to build resistance to change and unwillingness to assume new risks and learn new skills outside the existing areas.

On the other hand, it is also important to underline that the pressure to transform – in our view – to a lesser extent is about matching the production costs of the competition. Danish suppliers probably have world leadership when it comes to handling and exploiting new production technology. Not surprisingly, the implementation of robots and automated production technology and the transition to more efficient ways of organising production have proven to represent only a minor problem to the many companies we visited. This trend is also witnessed by the fact that many Danish suppliers have invested heavily in robotics over the past few years (Nielsen, 2011). Our company visits demonstrate that this trend must continue if Danish suppliers are to meet the requirements defined by the global competition not only for low production costs but also for production consistency.

However, The transformation process is also very much about creating organisational flexibility, including the ability to support the global activities of existing customers, as the Danish suppliers become part of the new Asian manufacturers’ supply chains. However, the suppliers are not the only ones needing to change their behaviour. If the manufacturers wish to retain and expand the strategic competitive edge represented by the Danish suppliers, it is about time that they take this task seriously. Building competitive strength through access to a superior supply chain not only requires investments by the suppliers. By changing their behaviour in the form of more long-term agreements and by helping the suppliers build relational skills, the manufacturers may help to relocate competitive strength to the
global onshore market. As appears from the discussion below, we find that retaining focus on the onshore market will be critical for staying competitive going forward, even though the opportunities offered by the offshore market have become the centre of attention.

The headlines of the four challenges we believe to be most critical for the market players are:

1. Development calls for unlearning
2. Good suppliers rely on good customers
3. Competence profile of suppliers challenged by new forms of collaboration
4. Local competitive strength requires global presence/flexibility

**Challenge #1: Development calls for unlearning**

Danish suppliers have been important collaboration partners and problem solvers in the evolution of the Danish wind turbine industry. In the early years of the industry, component design and production often took place in networked collaboration between suppliers, research institutions and turbine manufacturers (Andersen & Drejer, 2006). A number of studies conducted throughout the past 20 years have documented that Danish suppliers in the wind industry have played, and continue to play, a leading role in relation to technological advances in the industry (Andersen & Drejer, 2008; Garud & Karnøe, 2003; Karnøe, 1991). Supplier know-how in particular has played a role in the development and improvement of new generations of wind turbines. In this context, the ever-larger and heavier turbines have presented new challenges with respect to using new materials or rethinking technical solutions that would modern wind turbines machinery to withstand the heavy load they are exposed to, operate in many different climates, while at the same time being designed for as long operating periods as possible to avoid expensive down times when the turbine is idle. Throughout the 1990s and some years into the 2000s, the ability to develop the best and most robust mechanical solutions was the absolute key supplier contribution to the competitive strength of the manufacturers. Obviously, it was also important that the suppliers were able to supply the right components to the manufacturers, but the supply regime was very different back then. It was not more than a few years ago in 2006, that the then quality manager of Vestas’ referred to wind turbine production as “serial production of prototypes” implying lamenting that wind turbine components were too often replaced during operations as design weaknesses were discovered. Developing new, more robust solutions remains important, and some suppliers have even taken this a step further through technology solutions developed directly between the suppliers and knowledge institutions. A Danish scientist illustrates such a partnerships as follows:

> We’re developing [a blade] with an adjustable trailing edge. […] It involves smart materials that we apply voltage to in order to bind them together. […] We are developing a solution based on pneumatics, or pressurised air. [The supplier business] forms part of this project.

The scope of collaboration between suppliers and universities/research institutions has not changed during the past five years. In the present survey, 46% of the companies indicate that they exchange knowledge about wind power with university research environments,
primarily in Denmark but for the foreign-owned companies also to a great extent with international institutions. In 2006, 45% responded “YES” to the same question. Although the proportion of companies with this type of relations is unchanged, we assume – based on the corresponding survey conducted in 2006 showing a strong increase in the number of patents taken out by suppliers – that partnerships are increasingly being formalised and the suppliers increasingly develop know-how with a view to patenting such know-how in order to gain a stronger position in the market for knowledge solutions.

The possibility of providing leading-edge technology solutions has been, and in many regards remains, a key motivator for being a supplier to the wind industry. Interviewed suppliers also emphasise that their development skills in the fields of components and materials are material to advancing their customers’ R&D activities and, ultimately, their competitive strength. The ability to test the load capacity of materials and design or manufacture specific components are still highlighted as key differentiation factors when it comes to retaining and developing customer relations.

A breeding ground for the wind industry, Denmark has been the central scientific knowledge hub in the field. However, in step with the globalisation of the industry, knowledge is now increasingly being accumulated outside Denmark as well. As a result, it is no longer sufficient for the suppliers to draw on Danish scientific sources if they wish to secure a future role in the industry’s global value chain. As shown in chapter 2, Danish-controlled companies are less inclined to collaborate with universities than the foreign-controlled companies are and, as mentioned above, the Danish-controlled companies in particular do not collaborate very much with foreign universities on wind power. The reason may be that many of the Danish suppliers are relatively small and therefore do not necessarily have the resources required to take part in international research partnerships. Collaboration with universities is not the only source of external research, but there is much to indicate that the Danish suppliers would benefit from closer ties with research environments both in Denmark and abroad. In light of the developments in customer needs described later in this report, the players should not focus only on wind-technical knowledge but just as much on knowledge that may improve the companies’ process and logistics skills.

Strong focus on processes and costs

As described in the previous chapters, turbine manufacturer business conditions models have changed substantially. Owing to the pressure to reduce the CoE, manufacturers must also focus on streamlining their product and production processes – as well as being able to take greater responsibility in the global establishment of sites. These considerations lead to reorganisation and re-prioritisation among manufacturers, changing the relationships with the suppliers. The supply of components are increasingly being formalised and controlled by a supply department which increasingly influences the choice of and collaboration with the suppliers. A stage of trimming the production process and value chain considerations, partly inspired by the automotive industry, but perhaps even more the construction equipment sector, has moved a step closer. One turbine manufacturer says:

Of course, I would like the supplier to agree by saying: “Okay, I understand what it is you want. You bring me a component looking like this, but if I were to decide you should make such and such changes because that would make it cheaper for
me to manufacture”. That is the dialogue I’m looking for … that we then compare it against … how can we constantly optimise things? His innovative skills, … it’s in the process … that’s where his skills are superior. Then he wants components or goods which look this way because they most easily matches his process. In other words, the process drives part of the design.

This change of priorities and focus is already widely seen among the suppliers, but at the same time they have been able to balance customer-side demands through their relations with the production and development managers of the customer organisations (Andersen & Drejer, 2009). However, market demands for more and quicker ramp-up are shifting the internal balance of power and influence between the customers’ various departments and the role of procurement departments as strategic go-betweens between the customers and the components or systems suppliers is strengthened. Their task is to prioritise the implementation of systems enhancing reliability of supply, quality management and volume. These systems will to a great extent challenge other systems and priorities, including the more organic and informal metabolism between development/production and the supplier base-contractors.

Basically, there is a gap between supplier priorities and customer expectations. The ability to supply the best component or the best-performing system or the ability to be a party to ongoing improvements of already installed MW is not in as much demand as previously, nor in the same manner. Basically, there is a huge difference between designing in relation to improving the performance of a single wind turbine component and designing with a view to reducing average total costs of a wind power plant. In the case of the latter, the players need to think beyond performance of individual components and to a far greater extent think in terms of the customer’s total costs of manufacturing, installing and servicing the turbine.

The change of mindset required is very well exemplified by a company that has served as a component supplier to the wind industry for more than 20 years. Over the past two years, the company has restructured its organisation to match changed manufacturer requirements. It has an independent development department for wind power employing ten engineers and has consolidated its production skills in Eastern Europe and China. Furthermore, and importantly not least in relation to the discussion about changing customer requirements, the company has developed its collaboration skills with the turbine manufacturers with a view to supporting their development abilities. In addition, drawing on its know-how as a supplier to the automotive industry, the company contributes to expanding the end manufacturers’ knowledge in this field. They do this for example by hosting seminars for the customers’ quality management personnel on Advanced Product Quality Planning (APQP) and other process standards from the automotive industry.

This makes the company an ideal sub-supplier – from the point of view of manufacturers such as Siemens or Vestas – because it has adjusted their development process from developing “the best” from a purely technical viewpoint to developing something that is “good enough” for the system in which the component is to be used by the customer. To the question of how CoE considerations affect the supplier-contractor company’s development deliberations, they replied:
We solve this issue by saying that we can provide a cooler requiring lower pressure, allowing the customer to use a smaller pump and therefore also a smaller electric motor. If we can do what Vestas and Siemens do and come up with a good solution ... passive cooling, well that completely eliminates the electric motor ... so this is definitely something we need to consider – even though not all customers are prepared for such measures.

In other words, Danish sub-suppliers retain unique wind power competences accumulated through long-standing experience from the wind industry and other related industries. You could say that many Danish suppliers-contractors have evolved together with the industry. However, a recurrent theme of this report is also that the wind industry no longer has its hub in Denmark but has evolved into a rapidly growing global industry. As illustrated above, the industry has also reached some degree of maturity with focus increasingly being on efficiency and stable shipments rather than on joint problem solving and learning by doing. As a result, the role of the suppliers-contractors is gradually changing and the competitive edge they held previously through their skills as flexible problem solvers and collaboration partners is being challenged. In the words of one wind turbine manufacturer:

What is becoming less and less relevant is the ability to be flexible and realign things and address the challenges [...] So these days it is increasingly the ability to bring the process relatively quickly from the drawing board to an industrial process that consistently produces the same result, and in this regard the Danish suppliers are falling a bit behind [...] The Danish suppliers still have the ability to be innovative and flexible, and they are typically the ones we approach if we urgently need five or ten specific components, and they are in fact quite good in such situations … but that is not our bread and butter...

This statement underlines the fact that, as turbine manufacturers increasingly demand price efficiency, stability and speed, the value of the sub-suppliers “old” competences – their ability to be innovative and flexible – is eroded. Innovation needs changing over time and process innovation becoming increasingly important relative to product innovation is not in any way a feature unique to the wind industry. On the contrary, this represents a typical industry life cycle: while the industry is in its infancy and production volumes are relatively low, product experiments are carried out, while focus on an efficient production process grows as the industry reaches a phase with high production volumes. This is not to say that the product is not still being developed – ever-larger turbines are still being developed in the wind industry – but the product development process is also focused on optimising the price per performance unit.
New roles and relations
As illustrated in the network map in Figure 20, the Danish sub-suppliers still widely consider themselves to be knowledge partners to the turbine manufacturers.

Figure 20: Danish supplier network of a turbine manufacturer. Black markings represent pure product or service suppliers. Blue markings are product/service and knowledge suppliers – from the point of view of the suppliers. Green marking represents the turbine manufacturer.

The network map is based on supplier responses to questions about whom they had supplied products/services and knowledge to. The map shows the supplier network for one of the large Danish turbine manufacturers, and what is remarkable is that the bulk of the suppliers indicate that they have not only supplied products/services but have also shared knowledge with the customer, i.e. the turbine manufacturer, within the past three years.

In most cases, the suppliers identify themselves as knowledge providers to both of the two large Danish wind turbine manufacturers. Figure 21 shows one of the Danish turbine manufacturer’s knowledge network, indicating which of the manufacturer’s knowledge suppliers have also said that they share knowledge with the other large Danish turbine manufacturer. The black markings represent the knowledge suppliers not shared with the other turbine manufacturer, while the blue markings are shared knowledge providers. Again, note that the map is exclusively based on supplier responses, while the turbine manufacturers’ assessment of the nature of the relationship is not included.
Interestingly, however, we see that foreign turbine manufacturers establishing operations in Denmark seem to build their own unique knowledge networks with suppliers. Figure 22 shows, once more from the point of view of the supplier, a map of Chinese manufacturer Envision Energy’s knowledge provider network in Denmark. About one-third of the knowledge providers are unique to Envision in the sense that the suppliers have not indicated that they have shared knowledge with turbine manufacturers in Denmark other than Envision. However, the suppliers may have shared knowledge with other suppliers who form part of e.g. Siemens’ or Vestas’ knowledge supplier network. We see that Danish suppliers do not necessarily rely on close relations with the large Danish turbine manufacturers in order to play a role in the Danish wind industry.
Denmark – the Wind Power Hub; transforming the supply chain

Figure 22: Envision Energy’s Danish knowledge supplier network. From the point of view of the suppliers

As mentioned above, the network maps of knowledge relations are based exclusively on the suppliers’ perception of the nature of their relationship with the turbine manufacturers. The trend towards turbine manufacturers decreasingly considering supplier knowledge contributions as crucial to their business means that the suppliers must unlearn old habits and prepare to play a different role vis-à-vis the customers than before:

Roughly speaking, I actually don’t care because I just want the right relationship between key parameters, and these are of course price, quality, reliability of supply, dialogue and supplier innovation. […] This [process innovation/lean] is not something they [UL] can provide. If it were up to the suppliers, they [the turbines] will become more and more sophisticated.

The trends seem to indicate that the Danish suppliers – using a term from the innovation literature – need to undergo a creative destruction process in which they unlearn old ways of doing things in order to evolve the way customers demand. Many suppliers have already implemented this process and have found their new role in relation to their customer. One aspect of such a new role was illustrated above by the component supplier who now delivers a product that is “good enough” instead of the – from a purely technical point of view – “best” solution. Another aspect which means that the supplier must often prepare to get involved at a later stage of the process is illustrated by another supplier.
With respect to Siemens, they have already designed the concept, the idea concept and [...], that’s typically we’re we come in when they want us to manufacture some of the components, that’s how it works today. This is a major change from previously when we were involved in the entire process, right? They want to control the process themselves now. Fair enough, we say, that’s their strategy.

The fact that the suppliers are no longer as often invited to “be a part of the entire development process” does not mean that the knowledge contents of supplier contributions will be reduced going forward. However, recent trends indicate that individual competences must increasingly be combined with competences anchored in the organisation to ensure that the suppliers can provide – and especially document – consistent quality in large volumes. One turbine manufacturer illustrates this trend.

A Danish supplier [...] relies heavily on individual people’s backgrounds and training, and all that [...] is quite useful in many contexts. Typically during the production stage or when you need to be a bit intuitive and make things happen [...]. But when it comes to regular shipments, individual competences are of course a parameter, but only one of many. What matters most to us is their ability to consistently provide the same quality and the same delivery performance and, of course, at a competitive price. And with respect to these parameters, being able consistently to document this ability, that is where [...] we see that Danish companies need to catch up and find it difficult to grasp the situation and actually respond to it.

Localised relations
The final aspect we wish to highlight in connection with the challenge of unlearning is that the – often long-standing and personal – relations that have been built between suppliers and turbine manufacturers in Denmark are not easily applied in a relocation abroad. As a result, as an ever-growing proportion of wind turbines are being manufactured outside Denmark, suppliers must increasingly promote themselves anew towards customers they may otherwise be inclined to consider as close customers:

What matters to us is the attention to regional differentiation break up, where I may be able to build relations with customers in the US market, and also in China, right? You might say that I get three customers instead of one. [...] Because the USA is run more or less as an independent region [...]. We then need to talk to the Americans about how they wish to run things, right? [...] So even though we’re still dealing with Siemens, they may implement some changes you see.

However, potential benefits are that the experience built in terms of establishing new relations with “Danish” customers abroad may also be applied when seeking new customers in the foreign markets, so the customer portfolio can be expanded to consist also of some of the up-and-coming turbine manufacturers. Relative to some of these customers, the suppliers may sometimes get to play the same problem-solving role that they had previously with the Danish customers – but now in a completely different cultural setting that calls for adaptive skills and presence:
When we work with the Chinese, you know we play by intuition. Okay, sometimes we make a few mistakes, but then we rectify them, so it’s almost like it was in Denmark about 20 years ago, right?

[...]

For three years, we negotiated the contract for such a JV [joint venture]... You know, they say that is fast in China, but then we spent the time getting to know each other... I have probably been to China around 40 times ... and they have also been to Denmark.

Accordingly, there are multiple requirements for Danish suppliers seeking to position themselves in global value chains, including both comprehensive technical skills and broad organisational and/processing capabilities. In return, there is a large and growing potential market.

Summing up, the challenge; that “development calls for unlearning”, basically entails that supplier flexibility and problem-solving capabilities are no longer in as strong demand among the large Danish turbine contractors as they once were. Today, demand centres increasingly rely on process optimisation and consistency in delivery shipments. In addition, the Danish suppliers must increasingly prepare themselves to look beyond Denmark’s borders – both with respect to accessing the latest know-how and with respect to identifying new customers who also seek the suppliers’ traditional “problem-solving skills”.

Challenge #2: Good suppliers rely on good customers

As mentioned in chapter 2 and under challenge # 1, the wind turbine manufacturers do not always believe that the Danish suppliers are able to meet demand, especially when it comes to process and value chain optimisation and documentation of manufacturing quality.

As the industry has matured, quality enhancement methods such as Six Sigma are starting to be used. For example, Vestas believes that its strengthened focus on quality throughout the value chain that it achieved owing to Six Sigma deserves a great deal of the credit for the 7 MW turbine launched by Vestas for the offshore market in the spring of 2011:

I think it’s safe to say that if we had not started talking Six Sigma in 2005 – started talking about how we could transform this into a more quality focused value chain, which was to be established completely on a par with the aviation industry and other industries – then this would not have been possible. (Ditlev Engel, CEO of Vestas Wind Systems in an interview with Ritzau Finans in London, quoted in Danish daily JyllandsPosten on 31 March 2011)

Used in many industries such as the aviation and auto industries, Six Sigma builds on enhancing value to the customer by reducing errors, and it may drive cost reductions and performance enhancements in the value chain. However, optimising value chain relations requires great trust between the parties involved, and the associated supplier development requires that both customer and supplier are prepared to make a long-term joint effort (Want, Du, & Li, 2004).
The supplier must be prepared to undergo continuous performance evaluation. On the other hand, however, the customer must make a commitment in terms of acting as the sounding board that the suppliers need in order to develop their skills and performance – for example by way of clearly defined requirements on which engineering standards and quality verification requirements the suppliers must meet. In this regard, the turbine manufacturers still have a thing or two to learn. In the words of one of the Danish manufacturers:

There is a price to pay for having closer ties, and that price will often involve having to comply with well-meant, but firm, guidance on optimising products and processes, so, other things being equal, I believe that we will be moving towards the ways of the automotive industry [...] That, in turn, places demands on players like us [the turbine manufacturers] that we must be able to act as a sounding board to them [the suppliers], and we are not properly equipped to do that yet.

In step with the entry of many large, international players into the wind turbine market, and the resulting sharpening of competition, the ability to compose and manage a complex chain of suppliers will present one of the coming years’ key challenges for the well-established Danish wind turbine manufacturers. This is the assessment proposed in a PhD thesis by Mads Hovmøller Mortensen from 2011 (Mortensen, 2011).

Mads Hovmøller Mortensen draws parallels to aircraft engine and car manufacturer Porsche. During the 1990s, Porsche outsourced a large number of its processes to suppliers and currently reaps about 85% of its added value from its suppliers. The assessment is that the wind turbine manufacturers now need to undergo a similar process and that the ultimate goal for the turbine manufacturers should be a kind of sophisticated development houses that to a greater extent run the processes via the suppliers than handling the entire production in-house:

As an industry matures, an efficient supply chain and extensive process know-how becomes increasingly important to a company’s competitive strength. Consequently, Vestas and other industry pioneers must learn how to spin off a far greater proportion of the value chain to suppliers (Mads Hovmøller Mortensen in Danish trade journal Ingeniøren, 25 March 2011).

If this assessment proves correct, it merely emphasises the need for the turbine manufacturers to become more skilful at developing their suppliers and optimising the value chain. However, developing and value-chain optimising customer/supplier relations naturally does not only make demands on the customer; it will also result in mounting pressure on supplier skills. One component supplier underlines the attention to this issue among the suppliers:

If we look once more at supplier quality ... all the demands that constantly improve our skills, and I constantly say within our organisation: “I agree that it is indeed a tiresome process”. However, try to think about all the times that we are able to meet their demands. […] Every time we meet their demands, we grow stronger and stronger and branded more and more. […] My point is that if we’re able to
meet their demands and cope with the pressure, we will have vast opportunities to sell our products and services to other industries.

As mentioned above, one prerequisite for mutually developing customer/supplier relations is that they have a relatively long time horizon. The wind industry is in many ways a capital-intensive industry, also in the supplier link. In this connection, the suppliers find that it may require expensive – and therefore also long-term – investments to meet the turbine manufacturers’ demands, but the turbine manufacturers increasingly are only prepared to enter into short-term agreements with the suppliers. This not only restricts the manufacturers’ contribution to developing their suppliers, they actually pass a disproportionately high risk onto the suppliers, who are already under pressure due to lack of access to credit. In the words of one supplier:

“We sign a 1-year contract at a time, and that makes it fairly difficult, increasingly so, when we have to invest … for example we have machinery … the most expensive one costs 20 million kroner alone. It is a very big gamble to invest like that on the basis of a 1-year contract.

One of the other suppliers adds:

… we ended up winning the order after all, and we did that because we were agressive and made the necessary investment, right? […] the problem is that the same companies have no intention of making long-term commitments.

As such, if the Danish-based wind turbine manufacturers want to continue to have a highly qualified network of Danish suppliers, customer-supplier relations need to be improved and made more professional. This process requires that both sides make investments and adjustments, and it will combine old virtues such as trust with a higher degree of control and formalised relationships.

Challenge #3: Competence profile of suppliers challenged by new forms of collaboration

The suppliers to the wind turbine industry have been under pressure in recent years, and they are facing a fundamental choice: should they seek to stay on the current track, which they have developed to perfection, or should they make investments to truly develop into partnership-oriented suppliers forming part of Danish and international customers’ global supply chains?

Looking at employee qualification levels calculated as the average number of years of training for employees in companies operating in the wind industry, we see a slight increase from 12.9 years of average education for employees in 2006 to 13.05 years in 2012.

These figures would indicate that employee know-how has become an increasingly important input factor for Danish wind power companies. In companies operating in the wind industry, employees with 3-4 year further education programmes represented 25% of the workforce in 2006, or one in four. There are large regional differences between the
companies, and we will revert to that issue in chapter 5 in connection with the discussion about commercial policy challenges.

Looking at the Danish suppliers to the wind power sector, it becomes obvious that trends are moving towards more organisational commitment relative to the industry and the customers. The proportion of companies assigning the responsibility for wind power to a single employee has declined by more than 50% since 2006, while the proportion of companies fully specialising in or having formalised their commitment by establishing a dedicated division for the area has grown substantially.

**Organisation 2006**

![Organisation 2006 diagram]

**Organisation 2011**

![Organisation 2011 diagram]

Figure 23: Trends in organisation of wind activities in wind power companies from 2006 to 2011
These trends are consistent with the fact that, even despite the economic crisis and deferred investments, a large proportion of the suppliers in the survey expect to further expand their production, service and development activities over the next three years.

However, it is important for the ability of the suppliers to retain and consolidate their market positions that this trend not only covers the ability to develop components and trim customer technology designs but that, increasingly, it will also encompass the ability to build partnerships on the supply side and skillfully participate in the new supply regimes that the manufacturers are currently seeking to establish. A number of our informants point to the indicate that value chain relationships are becoming more hierarchical like, for example, those of the automotive industry. In such hierarchies, companies typically operate with different supplier tiers, with the top tiers performing the role of having system integrators: in other words, they are in charge of manufacture of own components, assemble components from other suppliers, handle quality assurance and deliver entire sub-systems to the wind turbine manufacturers. One manufacturer typically has a very small number of system integrator suppliers and they retain a status as development partners. Which means that The systems integrators play an important role in the development process and assume a joint responsibility for the production activities. On the other hand, suppliers without this function experience a much greater gap to the customer because their input to development and improvements are increasingly processed via system-integrated suppliers. Suppliers in the next tier typically have less influence and will most often be manufacturers of standard solutions developed upstream in the supply chain. Furthermore, the metabolism between the supplier tier and the customer will increasingly be controlled by a specialised supply chain management function in the recipient company. This evolution in the organisation of collaborations between suppliers and customers has been underway for some years now, but it has been accentuated by the need for to master greater volume production.

Figure 24: hierarchised value chains
Consequently, the ability to scale production in-house or by partnering with other suppliers will be an increasingly critical parameter for Danish suppliers seeking to retain a privileged position in the manufacturers’ supply chains. Danish suppliers have traditionally refrained from acting as large volume manufacturers. They have practised their development potential elsewhere – as suppliers to customers prepared to pay for flexibility, development abilities and high quality. Optimum performance in these areas means that you focus and prioritise. But it also means shunning other opportunities. If the Danish suppliers are to match the trend towards global and speed-to-market production on a large scale, in their future strategy plans they must prioritise in-house development or external competence building to underpin collaborations with customers and other value chain players. This means not only new types of employees capable of handling the new commercial and logistical challenges; it also means that the rest of the organisation must adapt so this becomes an area of priority.

However, we did not get the impression that this challenge is unknown to the suppliers. We interviewed persons from several supplier businesses which were either in the midst of or had already implemented changes towards addressing these challenges. It was characteristic of these suppliers that they were in the process of simultaneously automating and consolidating their global production organisation, were cultivating or had already built relations with a portfolio of wind turbine manufacturers and were involved in the logistical processes, while also having formalised their collaboration on development activities. One supplier explains the situation:

Let’s say that we’re talking about a new product. Well, then we make sure that we are able to deliver as promised... We have simulations and many other things that we align with our customer using the same tools that the customer uses and which are generally accepted in society. In this way, we know that we can deliver a certified and usable product and we deliver it, so to speak, safely from the region in which he wants it and in a global set-up, same product everywhere – and we provide a two-year warranty. We actually have a track record of delivering in case of adjustments, and then we of course have a logistics solution for all our products, right? We also help out ... in terms of globalisation we help with some of the requirements they face, especially the „local content“ requirements, right?

Our survey also shows that many companies expect to grow both in Denmark and internationally within all three principal activity areas: development, production and services. Service activities in particular are set for expansion both in Denmark and abroad, and this may reflect the fact that a group of suppliers are considering capitalising on the opportunities for increased local presence.
Suppliers and other players wishing to pursue activities in the wind industry of tomorrow must prepare themselves that this will require a substantially higher degree of specialisation relative to the industry’s changed requirements. This will call for considerable investment in competence building, organisational changes and revised strategic priorities.

**Challenge #4: Local competitive strength requires global presence**

In chapter 3, we pointed to arbitrage – the ability to exploit differences in prices, skills etc. across regional markets – as a key aspect of globalisation. But how do the suppliers capitalise on their arbitrage benefits and are there any examples of arbitrage creating specific advantages? The arbitrage benefits relate especially to suppliers with a presence in several regions and who use these positions to combine in-house resources (and know-how) with the access to external resources and skills that such presence opens up for. In this way, they gain a competitive edge over local players (Andersen & Christensen, 2005). AH Industries is an example of a Danish supplier utilising its presence in Europe (close to customer production sites) to make quick deliveries. When they combine the local, fast supply ability with access to and agreements with Korean suppliers of flanges, who after an extended shipment period are able to supply inexpensive products, they create a coordination benefit. LM Windpower is a good example of another supplier who, in a market with no serious international blade manufacturer contenders, successfully aligns its operations to different customer types and exploits its global presence to create local competitive benefits by employing regionally-based strategies and customers’ presence in several regions, thus increasing their need for one-stop-shopping and more knowledge hubs.
Another key aspect of economies of arbitrage from a supplier perspective is the ability to cover customers’ market needs in several regional settings. Pro-active suppliers in the wind industry already to a great extent relocate together with their customers when they internationalise their operations. In this way, they accumulate knowledge about local opportunities and skills, and this knowledge may also be used the other way around: to build a platform for becoming part of the supply chain to the companies which in the not too distant future will enter the European market. A precondition for doing so is that the Danish suppliers transform from selling designs and components to these foreign manufacturers to increasingly being part of the local “eco system”. In other words, they should not merely become a representative of Danish core skills, they should also start to exploit the local knowledge about wind power and technology being accumulated in these markets.

These examples merely serve to indicate the opportunities associated with strategic thinking and behaviour when coordinating localisation benefits in a semi-global market. The first step towards achieving this is to adapt existing priorities and ways of thinking to such opportunities. Suppliers only seeking to capitalise on cost benefits at one location and customer proximity and knowledge at another will forfeit arbitration opportunities. Next, the organisation needs to design the localisation of its activities in a way that facilitates acting in the different locations while at the same time ensuring coordinated operations. Responsibilities and priorities must be transferable rather than belong to one specific location. Having a global presence is subject to a greater organisational transition process towards more internationalisation. That, in itself, is a major task, and it is not made any easier by the fact that it often challenges conventional ways of thinking and established perspectives among executives of companies embarking on internationalisation processes. Studies of change processes in organisations have previously shown that it represents a challenge to introduce new skills and priorities in an organisation as they challenge existing priorities and convictions.

For this reason, we could – slightly provocatively – question the value of suppliers committing themselves too unilaterally to the future offshore market: is the offshore market a blessing or a curse in disguise in relation to becoming global companies if the competitive strength builds on local anchoring?

The offshore market and the development tasks associated with manufacturing new turbine types (such as Vestas’ V164) and adjusting other designs in many ways match the Danish suppliers’ development and production competences in small series. This is in fact consistent with the long-standing claim about good management practice: focus on core competences.

However, the challenge is that an overly unilateral focus and dedication may be a dead end for the companies. The core competences develop into blinkers, and although they may keep management focused and facilitate decision-making, too frequent use of the argument: “that is/not within our core competences” hampers discussions and innovative thinking among corporate decision makers (Leonard-Barton, 1992). There is no doubt that the offshore market will offer great order potential for existing Danish suppliers and that it may potentially create a market for suppliers still unknown to us. Furthermore, in the future evolution of the European offshore capacity, Denmark and Danish suppliers stand to enjoy
a distinct localisation benefit. Consequently, there is no doubt that many resources will be applied to conquering market opportunities over the next 10-15 years, and that some of the competences built can be applied outside Europe as other markets unfold.

The challenge is that the sharp focus will draw attention away from the challenges of change which will only have grown bigger on the other side of offshore capacity expansion. Developing capacity onshore will for many years ahead remain the principal market for wind power, and onshore turbines will also grow bigger and have a greater capacity. If the initiative in these markets is left in the hands of “the new manufacturers” and their supply chains, in the slightly longer term – perhaps sooner than most European suppliers imagine – they will also be prepared to step into parts of the European offshore market. It is therefore important that the suppliers retain and develop their internalisation initiatives.

All things being equal, in the near term the least complex solution will be to dedicate resources towards optimising the offshore market in Europe. However, the suppliers should build the skills to withstand future competitive pressure by entering the new manufacturers’ value chains. The major progression task for the management and the board of such companies will be to strike a balance between the operational and development tasks associated with the development of new turbine types and matching the requirements for large-volume production and global supply, and this in a market expected to see growing price competition in the years ahead.

The players of the Danish wind industry must increasingly acknowledge that they should no longer base their competitive skills exclusively on export base logics in which competitive advantages in the export markets are subject to access to a Danish component and knowledge market. Instead, these players must focus on the ability to group and exploit differences in cost levels and skills developing in the regional markets and combining them in order to create competitive advantages in the local markets where the players operate. Active exploitation of trade relation benefits will be the underlying driver of the wind industry in the years to come.
5. Denmark’s future as a wind power hub – commercial policy challenges

The wind industry has evolved faster than even most optimists predicted a few years back. From being an industry which had its absolute hub in Denmark, wind power has become a global business and the bulk of the international manufacturing capacity has moved from Denmark to Asia. As a result, commercial policy stakeholders and others need to change their ways of thinking in terms of the wind industry’s role and development potential in Denmark. Rather than defensively focusing on retaining Denmark’s position as a dominant wind power nation – including commercial policy initiatives or framework conditions designed to keep manufacturing activities in Denmark - the underlying question for this report is: Which value-creating activities in production, knowledge-building and knowledge- and operating services in relation to the wind industry would still be attractive and important for Denmark to pursue? The question implies recognition of the fact, that wind power developments are no longer predominantly a Danish speciality, and that Danish companies and customers – from playing a leading role in this industry – should prepare to participate in the global division of work. The outlook for the Danish part of the wind industry more than ever relies on Denmark’s ability to form global partnerships with other knowledge and production environments. This ability requires not only internal building of core competences but also the ability to interact, including the sharing and use of other players’ knowledge and skills. Secondly, we need to acknowledge that we must refocus if we are to contribute to promoting the industry’s conditions in Denmark going forward. There has been a tendency to look at the wind turbine industry’s opportunities for development as being dependent on technology advances and the ability of wind power to match the cost and output capacity of other sources of energy. This is still an important task, but it will no longer suffice if we are to retain, and perhaps increase, the number of “Danish” jobs in the wind power sector. The need to refocus is intensified by the fact that in the coming years Europe will make further investments in developing “intelligent” power grids that will enhance the grid’s ability to utilise and integrate different sources of energy to better match consumption and production.

It is important to note that changed competition and sales patterns for wind power will have consequences for commercial policy planning. Instead of regarding the technological challenges and innovation activities with respect to wind turbines as the driver of further development, and the commercial policy initiatives as a matter of creating the best framework conditions for technology advances, the industry should turn its attention to value creation and the role played by wind turbine manufacturer skills in this process. This also involves focusing on how to exploit the special access that Danish suppliers and manufacturers have to this kind of knowledge. Another effect is that we believe that more general and “blunt” commercial policy tools directly aimed at reducing cost levels are not particularly appropriate. In our opinion, the key challenge does not lie in applying regional, local or national commercial policies to match the global competitive conditions in terms of factor costs through low wages or artificial development of infrastructure to promote the players of the wind industry particular. It is important to bear in mind that payroll costs represent a relatively small proportion of the aggregate costs of a wind turbine. The basic challenge is
that, in the coming years, the development of, and investments in, new wind turbine capacity will take place outside Denmark and that Danish players need to be more committed to and locally active in this development if they are to have any hopes of retaining a position in the industry. At the same time, commercial policies must underpin the development of new skills covering broader aspects of the value chain and also comprising the integration of wind power in the existing grid. Effectively integrating wind power in the existing power grid – with the challenges and demand for problem-solving that this would create – could open up new business activities that only some of the existing players are capitalising on. There is a demand for entrepreneurial activity in this area, and such activities should be actively backed by dedicated commercial policy measures.

The objective of the commercial policy recommendations in this chapter is – based on the industry’s changed role – to discuss national and regional commercial policy measures that could enhance the global opportunities available to the wind industry. We have defined five recommendations based on the analysis of the preceding chapters but in a few cases qualified by additional data:

• Strengthening export initiatives in emerging markets
• Building skills to participate in global value chains
• Participating in more global knowledge networks
• Promoting process innovation across the value chain
• Exploiting and developing different regional strengths

**Strengthening export initiatives in emerging markets**
Promoting collaboration between Danish suppliers and international players in the form of customers, knowledge institutions and other suppliers represents a commercial policy challenge. For a number of reasons, it would not be a realistic commercial policy vision to see Denmark as the future manufacturing hub. First of all, the manufacturing skills of the Danish suppliers in the field of wind turbine components are not distinctive enough to create sustainable competitive benefits. The skills of the suppliers in this area are overtaken by foreign suppliers. On the other hand, suppliers capable of handling this transition will have huge opportunities to become active partners in the operating and development processes that the global players have implemented in recent years. Through active and committed participation in emerging markets activities, the Danish suppliers may have the opportunity to expand their production and activity focus and become global suppliers capable of exploiting arbitrage opportunities. The ability to handle this task while also retaining significant operations in Denmark has already been demonstrated in a number of other industries undergoing a globalisation process. It is unlikely, however, that all the existing suppliers to the wind industry will be able to carry out the transition from being a locally-anchored export business to becoming a global player based in Denmark – at least not in their present form. On the other hand, some of the existing suppliers are likely, through collaboration or acquisitions, to position themselves as global suppliers.

Danish suppliers remain too focused on the domestic market. Only through more active participation in international labour and knowledge-sharing initiatives will the suppliers be able to retain and develop their skills. Active commercial policy measures aimed at
promoting supplier commitment in the supply chain of global customers – in addition to acting as suppliers of prototypes – are necessary. Such participation requires greater commitment in foreign markets, including the establishment, management and development of production activities in the target markets rather than in Denmark. Our impression in this context is that the suppliers face particular challenges when it comes to managing international operations.

Accordingly, there is a need for a dedicated commercial policy globalisation initiative towards the Danish suppliers to the wind industry. Such an initiative would benefit from the experience of more general globalisation efforts but should be adapted to the specific challenges and strengths of the wind power suppliers.

Building skills to participate in global value chains

In other surveys, Danish suppliers have been characterised as being very active and innovative in terms of developing their customers’ products and prototypes. This particular characteristic of the Danish industrial structure has also been noted internationally. However, the Danish model is undergoing change because production activities are being globalised and the division of supply chain activities is becoming increasingly global. This globalisation is putting severe pressure on the business model applied for many years by the Danish suppliers. In the original model, which dominated collaborations between Danish manufacturers and their suppliers, the suppliers primarily generated value through partnering with customers in the fields of technology and development. The production and development activities were to a great extent located in Denmark – even though the customer base was international and the suppliers also helped servicing customers internationally, through the design and adaptation of solutions in collaboration with their customers. Consequently, the customers also paid relatively high prices for components and solutions from these Danish suppliers compared with the cost price for similar components in countries with access to cheaper production factors. The higher price reflected the suppliers’ knowledge contribution to the customer, and in this way it helped strike a balance in the relationship between customers and strategically important suppliers. By contrast, the Danish suppliers only have limited experience in acting as supply partners in connection with global volume production. This role brings new challenges in terms of being able to establish, organise and monitor product flows, finances, documentation and information flows across a network of suppliers and between the responsible supplier and the customer. These changes interfere with the suppliers’ organisation, placing new demands on their organisational development and competence building. This challenge – which in principle is relevant not only to wind power suppliers but affects all the suppliers currently seeking to build an international presence – could potentially be addressed through development programmes aimed at these processes. This task could also be left to the regional business promotion organisation – alone, or more ideally, in collaboration with trade organisations or similar bodies, and discussions on partnering with universities and other educational institutions about training programmes and designing of masters’ degrees in engineering and business finance, with respect to these needs, would seem relevant. However, it may also be relevant to incorporate training programmes at other levels or as tailored post-graduation programmes.
Participating in more global knowledge networks

In relation to the above discussion about the need for increased globalisation of Danish suppliers, our survey shows that a substantial part of the Danish wind power players are owned by foreign companies. This is an interesting trend by itself, demonstrating that the competences of the Danish wind power companies are considered valuable to foreign investors. From a commercial policy perspective, the survey indicates, however, that the nationality of supplier ownership is also correlated with another interesting aspect: there are large differences between Danish and foreign-controlled players in terms of collaboration with international knowledge providers such as universities. While the Danish players primarily collaborate with Danish universities, the foreign-controlled companies are far more open to the opportunities for knowledge exchange with universities outside Denmark, and a larger proportion of the foreign-controlled companies utilise university know-how. The survey shows that Danish companies are focused on Danish universities as knowledge centres, and still only a minority of the Danish suppliers pursue knowledge relations with universities.

There is a need for Danish companies to actively seek knowledge opportunities in other countries. Commercial policies can and should be implemented to promote this metabolism between universities and knowledge partners. On the international scene, well-established innovation centres such as Shanghai and Silicon Valley could play more active roles as knowledge scouts in this process.

Promoting process innovation across the value chain

If Denmark is to focus its commercial policies entirely or partly on retaining competitive strength in the Danish wind industry, we must adopt a broader focus on industry challenges. To a much greater extent than previously, value in the industry is generated through interaction between production, knowledge and logistics. In other words, we need more than just research into the areas that directly support the development of wind turbine technology. The correlation between product and process innovation, especially knowledge about, and active support for the development of supply chain skills, is paramount to the promotion of the wind industry. This task of developing practical value chain skills is difficult to accomplish for the industry’s own players, probably because of its cross-functional nature. The industry is facing a special business development task of establishing, for example, new network partnerships to support systematic dialogue and knowledge sharing across the value chain. In other words, collaborations that address the challenges of the entire value chain, instead of only focusing on challenges relating to the closest business partners. The dialogue and knowledge-sharing process should centre on solving logistical bottlenecks and challenges.
The industry players must prepare themselves before they are ready to enter into a dialogue about the possible connections and challenges that are the root of the weaknesses, that are especially experienced and identified by the manufacturers. On the other hand, tackling this process in the right way would probably lead to substantial process innovation opportunities, and these opportunities may also be underpinned by process standardisation considerations. Such dedication to process innovation in the value chain would also require that each company dedicates more resources and more management attention to building competences in coordination, configuration and optimisation of production activities; in other words, process innovation in the individual companies.

Developing and exploiting different regional strengths
This report focuses on the combined Danish wind industry. However, as the wind power companies are not evenly distributed across the country, we will close the report by discussing which region-specific measures may be required relative to the wind power sector. Figure 27 shows the geographical distribution of the Danish wind industry.
Figure 27: Geographical location of the Danish wind power companies. Background colours indicate the region’s share of total Danish employment in the wind power sector.
(Source: Industry statistics from the Danish Wind Industry Association (DWIA) and member list for the DWIA and the Danish Export Association’s Wind Energy Group)
In terms of employment, the Central Denmark Region accounts for more than half of all employees in the Danish wind industry (source: Industry statistics from the Danish Wind Industry Association), and the region is the most densely concentrated in terms of wind turbine manufacturers (Vestas’ and Siemens’ activities are spread across a number of sites). Accounting for about one-fifth of all employees in the wind power sector, is the Region of Southern Denmark. In southern Denmark, the companies are located primarily close to the E45 motorway, complemented by a small cluster around Esbjerg, as the city port has attracted a number of companies. The North Denmark Region, Region Zealand and the Capital Region of Denmark each accounts for less than 10% of total employment. Nevertheless, the Capital Region of Denmark is also home to a substantial number of wind power companies. However, there are more companies in this part of the country with a smaller proportion of employees working within wind power than is the case for the companies in the western part of Denmark. These include businesses such as consulting engineers and other broadly-oriented companies like ABB, which supplies products and services to a wide range of industries.

There are generally more manufacturing companies in the western part of Denmark than in the eastern part, and the wind industry is no exception. Jutland is home to the wind turbine manufacturers’ production plants as well as the bulk of the R&D activities, and the region also houses a relatively large number of manufacturing suppliers to the wind industry.

![Figure 28: Average number of educational years for employees working in companies with wind power activities, broken down by region, 2000-2006](source: Statistics Denmark)

This distinction is also reflected in the wind power companies’ formal knowledge level, expressed as the average number of educational years of the workforce. The wind power companies in the Capital Region of Denmark have the most highly-educated employees, while the Zealand Region has the lowest level of education. In this regard, however, it should be noted that there are very few wind power companies in the Zealand Region. In
between are the Central Denmark Region, the Region of Southern Denmark and the North Denmark Region (see Figure 28).

The companies in the eastern and western parts of Denmark thus differ in terms of roles and organisation – and therefore also in terms of which commercial policy measures are most meaningful to them.

From a regional perspective, the competency challenges discussed above for the production companies in the western regions of Denmark do not mean that all employees must have completed a higher education programme for the companies to catch up with the level of education seen in, for example, the engineering firms in the Capital Region. It is quite natural for production companies to have a lower proportion of employees who have completed a long-term higher education programme than companies providing knowledge services.

However, there may be a need to supplement the existing employee groups in the westerly located supplier companies with highly-educated employees in order to achieve the organisational and logistical skills required to strengthen the global presence and participation in global value chains.

Furthermore, it is primarily the western regions of Denmark that experience the need for securing continuing development of the production skills and investment in sophisticated production technology required to retain and develop the manufacturing suppliers’ competitive strength by constantly striving for higher efficiency and improved abilities to supply uniform components to global customers, no matter where the production takes place.

In other words, there is a need for production-related research and development investments – which is hardly a job the companies alone should undertake – as well as a need to create incentives for the suppliers to invest in production technology and process innovation. The latter factor, which to a great extent is about putting existing knowledge to work in the companies, may cost jobs in the near term, but in the longer term it is necessary to ensure that Denmark continues to have competitive manufacturing suppliers for the wind industry.

As mentioned above, the Capital Region is home to more service companies than the western part of Denmark. The wind industry is no different from the other industries in terms of the increased focus on activities relating to production measures and follow-up as sources of value creation. However, since wind power as a business area represents a relatively small share of the large knowledge-based service companies in the Capital Region, relatively little attention is given to wind power in the regional commercial development strategy for the Capital Region, including how the service companies may become better at exploiting the growth opportunities offered by wind power. The wind industry has attained a size that gives it substantial earnings potential for related services, and the service companies may benefit from learning from the manufacturing companies which, some years, back applied skills acquired in other industries as a stepping stone to gain a position in the wind industry. One such area could be logistics, where we have already seen examples of tracking know-how accumulated in relation to other product types being beneficially transferred to wind turbine components.
Furthermore, relatively little attention is given to how the regions can cooperate on utilising their different strengths. The fact is that there may be unharvested potential in a more comprehensive cross-regional collaboration, linking manufacturing and service skills across the value chain.

**Denmark’s future as a knowledge and production hub in the global wind industry**

This report follows up on the report entitled *Denmark as Wind Power Hub – between reality and opportunity* published in 2006. That report concluded that Denmark would have opportunities to play a role as a global knowledge hub in wind power if we were prepared to expand Denmark’s R&D activities.

During the past six years, the wind industry has continued along the global development track that was laid in the mid 2000s. The ability to retain and consolidate this position has attracted major investments to the sector, leading to a globalisation of ownership of wind power manufacturers. In a number of ways, this has changed the dynamics in the wind industry – both in Denmark and worldwide.

Another development trend characterising the industry is a substantial level relative to the special challenges involved in manufacturing, integrating and using wind power in an expeditious and financially feasible manner. The interaction with downstream players – the companies that mediate energy or use electricity as their driving force – has also left its mark on trends in the wind industry, and this trend will characterise the industry even more in the years ahead.

Among the commercial policy decision makers and the Danish part of the industry, there should no longer be any doubt that this is a global industry in most respects, and the remaining part is becoming so as well.

It is also important to recognise that Danish knowledge production within wind power, also in the future, will be anchored in production activities. A division of the value chain like in other industries, with production activities and development activities being kept separate and coordinated across large geographical distances, is only partly feasible in the wind industry. Here, knowledge is to a great extent built through local “seek-learning” processes in which know-how is accumulated through trial-and-error. Knowledge activities move to the location of the production. Consequently, the concept of a knowledge hub is partly misleading if knowledge and production are regarded as distinct and separate concepts. However, our analysis has shown that, despite the fact that Denmark no longer holds as dominant a position in the global wind industry as it used to, Danish knowledge institutions and companies still possess knowledge and skills – and not least experience – that makes the country attractive to companies seeking to build a position in the industry. However, our experience must not become an excuse for inaction. We need to continue to develop and transform the Danish part of the industry if Danish companies, also in the longer term, are to play a key role in this rapidly growing industry.
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