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Summary

This paper uses a value chain lens to examine the prospects for competition and cooperation between Europe and China in the global wind power sector. Drawing on insights from fieldwork conducted in 2010 combined with secondary industry data, we find that Chinese and European industries are developing distinct models of industrial-technological organisation. The usual headlines emphasising Sino-European competition or conflict fail to capture the complexity of current reality. While competition among lead firms is increasing, there are also considerable prospects for increased collaboration between firms across the value chains. China, Europe and the world can benefit from such collaboration to drive down the costs of the technology, improve quality, enhance innovation capabilities and make wind power a more credible energy option for the world. Policy initiatives in and between China and Europe have a big role to play in securing mutually beneficial relationships for the future.

Keywords: wind power; global value chain; competition; cooperation; Europe; China.

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Acronyms

B2B	Business-to-Business
CN	China
D&E	Design and Engineering
DE	Germany
DK	Denmark
ES	Spain
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GVC	Global Value Chain
GW	Gigawatt
IN	India
IPP	Independent power producer
JP	Japan
JV	Joint Venture
KIBS	Knowledge-intensive business services
MW	Megawatt
NDRC	National Development and Reform Commission (China)
O&M	Operation and Maintenance
ODIP	Organisational Decomposition of the Innovation Process
OECD	Organisation for Economic Co-operation and Development
PDRC	Provisional Development and Reform Commission (China)
R&D	Research and Development
WTG	Wind Turbine Generator

1 Introduction

The starting point for this paper is the observation of two major shifts in the global economy. The first is the shift of economic power from the West to the East. This is most clearly visible in the enormous build-up of industrial production capabilities in China. Correspondingly, trade flows in manufactured products from China to Europe (and other parts of the world) have increased rapidly over the last three decades. Trade flows in some sophisticated products, in particular capital goods, continue to be dominantly from Europe to China, but this is also changing with the ‘breakthrough’ in the transition from production to innovation capabilities in China (Altenburg *et al.* 2008).

The second big change is the shift from high to low carbon growth. This shift is underway in parts of Europe but only nascent in China. However, a ‘green’ turn is occurring in the sphere of political discourse in China. It is recognised that the green turn entails economic burdens but there is also awareness of the new investment and job opportunities in the green economy. These opportunities are now opening up new avenues in the global competition between firms and nations. The race is on to become the leading supplier of resource efficient technologies and solutions (WBCSD 2010).

Governments and industry in China and many countries in Europe have already made substantial investments in developing and producing low carbon technologies. This paper will focus on a key sector in which this has occurred: the wind energy industry. There is widespread agreement that wind power will be an increasingly important source of energy. Both China and Europe have made heavy investments in the wind energy sector: (a) to show their commitment to climate change mitigation; (b) to strengthen their energy security; and (c) to promote the competitiveness of their own industry and create new jobs in a sector thought to have great potential.

This paper investigates what this means for the global division of labour in the wind power industry and the relationships between Europe and China. Are these relationships characterised by cooperation, competition or conflict? What are the future prospects in an industry which is both expanding globally and integrating internally in the European Union and China? These are the key questions addressed in this paper.

In addressing these questions, the paper benefits from and contributes to a hot debate conducted in academic, policy and business circles. There is agreement that a fast growing and technologically vibrant international wind turbine sector helps to reduce carbon emissions (Kirkegaard *et al.* 2009). By contrast, there is no agreement about whether growth in this sector will occur in cooperation between Europe and China or through competition or even conflict.

The prevailing view is one of conflict. The debate on wind power takes place in the context of the need for global reduction of carbon emissions. While recognising that international cooperation is essential to reduce these emissions, inter-governmental negotiations over targets have made little progress. A global deal has not emerged. Conflicts between the old powers of Europe (and the US) and the rising powers of China (and India) have not been overcome. A pessimistic point of view also prevails in analyses of the wind turbine industry. The business and political press gives a picture of zero-sum relations and conflict between the EU and China in the wind turbine industry (Hamlin 2009; *Nature* 2009; *China Daily* 2011; *Shanghai Financial News* 2011).

This paper questions this view and suggests that the relationship between Europe and China in the wind power sector is characterised by a combination of competition and cooperation. More importantly, it argues that the view one comes to is influenced by the way one approaches the question. The approach adopted in this paper involves: (i) grasping the entire value chain; and (ii) adopting a dynamic approach. Observing the entire value chain (not just the wind turbine manufacturers) and observing changes over time (not just a specific point in time) leads to different conclusions. We show that the combination of adopting the value chain approach and observing dynamics leads to new insights.

Section 2 explains our approach. It sets out what a global value chain is, both generally and in the case of the wind power industry, and it highlights the analytical potential of this approach, both generally and specifically in the case of wind power. Section 2 then explains why understanding the dynamics is so critical. The main markets for wind power are shifting and this has ramifications for where different parts of the industry are located. Locational dynamics and power dynamics in the value chain interact. Since it is essential to understand these power dynamics, we pay most attention to the lead firms of the value chains, their locations and their relationships with suppliers and government. The empirical basis for the analysis is also explained in Section 2.

The empirical findings are presented in the sections that follow. Section 3 shows how the wind power lead markets are changing in the global economy. While Europe is the traditional leader in turbine production, the lead market in terms of demand is now shifting to China and its turbine lead firms are now among the biggest in the world in terms of market shares. In Europe, Denmark and Germany are the most significant players; they use a large amount of wind power in the electricity market – 21 and 9 per cent respectively (WWEA 2011). By contrast, wind power contributes only 1.2 per cent to the overall electricity supply in China. Together, lead firms from China, Germany and Denmark account for close to 60 per cent of world wind turbine sales. In 2010, Chinese firms ranked first, accounting for approximately 31 per cent of worldwide wind turbine installation. The capacity produced by Danish and German companies – ranking second and third – account for a total of approximately 28 per cent. If all EU countries are included, Europe is still leading on the producer side. However, China is the largest and fastest growing market in the world.

Section 4 analyses the European wind power industry, focusing mainly on the two leading producer economies, Germany and Denmark, while Section 5 analyses the Chinese wind power industry and its relationships with European investors. These sections show the value chains in Europe and China and the linkages between them. Europe has highly developed wind power value chains while the Chinese industry value chain is in its nascent phase. But both value chains are changing rapidly and restructuring on a global scale. The analysis of markets and value chains for the industry is not limited to these three countries. On the contrary, understanding the markets of other countries and continents is essential for understanding the relationships between the main producers. Most attention, however, is given to the analysis of China because this is where the big changes are happening and these changes have significant global ramifications.

Section 6 pulls together the key insights and sets out the implications for Europe, China and the world. A scenario of global cooperative competition is contrasted with scenarios of global cut-throat competition between enterprises and of conflict between nations. One of our central arguments is that the possibilities for cooperation are enhanced by the globalisation of the wind industry. The positive outcomes, however, will not occur automatically, they require government intervention.

These conclusions are derived from our business-focused analysis. We focus mainly on the value chains that link China and Europe in this sector. A comprehensive analysis of the relationships between Europe and China in the wind energy sector would need to focus on a wider array of factors, in particular the relevant government policies. A number of policy-focused studies have already examined Chinese relations with the wider world in renewable energy, including with the European Union (Conrad and Meissner 2011; Delman and Yong

2008; Umbach 2010; Holslag 2010; Lewis 2007). The dominant view is that the nature of future relationships will depend on whether China adopts a market-based or strategic approach to renewable energy. For wind power, China has so far pursued a strategic approach which has techno-nationalist underpinnings. China seeks to develop a domestic renewable energy industry irrespective of market forces. Despite this, we argue that a future scenario of 'competition with cooperation' between China and Europe is more likely than the 'competition with conflict' scenario.

2 Research approach

This section presents the analytical approach and information sources used for understanding whether and how the European and Chinese wind power industries compete or cooperate.

2.1 Conceptual approach

Many studies have examined the wind power industry in Europe and China (Han *et al.* 2009; Recknagel 2010; Ek and Soderholm 2010; Balat 2011). These studies are of limited use for our purposes because they do not capture what goes on between enterprises. For our purposes, global value chain (GVC) analysis (Gereffi 1999; Schmitz 2005; Sturgeon *et al.* 2011) provides a useful framework because:

- It is concerned explicitly with relationships between enterprises in different countries;
- It emphasises that the relationships between enterprises within and between countries can be organised with different types and degrees of outsourcing and chain coordination;
- It is concerned explicitly with power relationships between firms, especially the relationships between lead firms and suppliers.

Global value chain analysis is rarely sufficient on its own but it is essential for understanding how industries, localities and linkages evolve and it gives insights into how they might evolve in the future (Sturgeon 2009). GVC analysis draws attention to three features of global industrial organisation that are particularly relevant for our purposes:

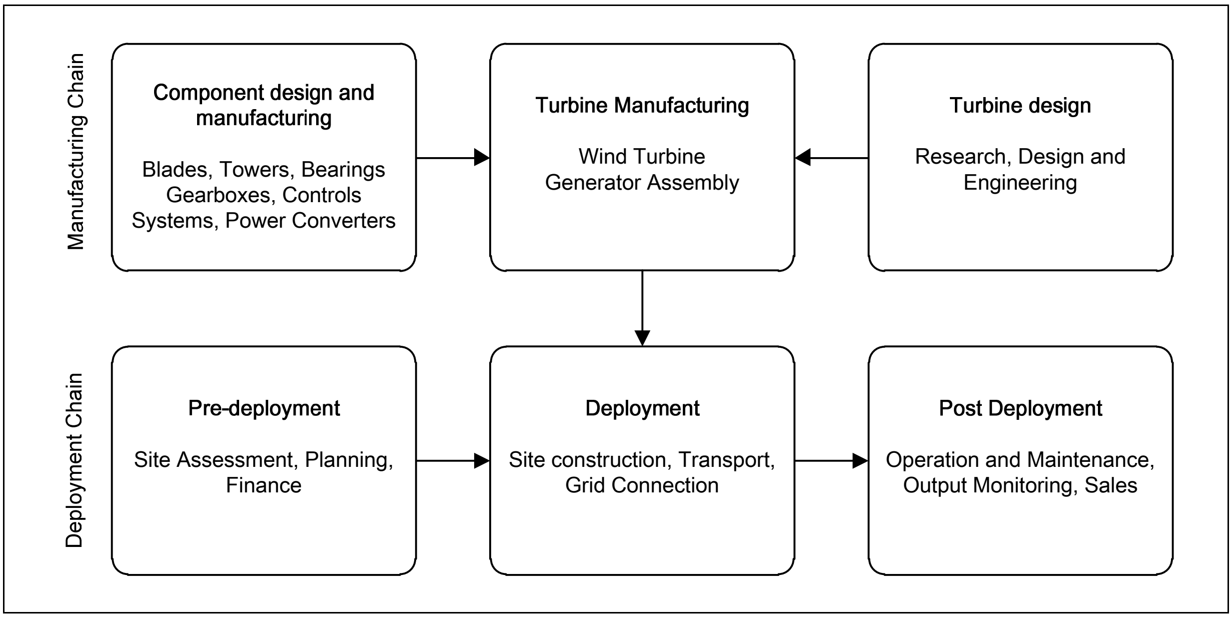
- Competition in one part of the chain can co-exist with cooperation in other parts of the chain and both occur often across national boundaries.
- Public discourse about competition or conflict between countries makes little sense when they are linked through value chains, with lead firms in one country and suppliers in another country.
- Power relationships change over time, because: (a) suppliers gain capabilities that increase their options and reduce their dependence on single lead firms; and (b) the lead markets change over time (typically due to market saturation in rich countries and market growth in emerging economies).

The latter point is particularly important. It stresses that a dynamic approach is needed because: 'Existing producers, or their spin offs may acquire new capabilities and explore new markets, and this changes power relationships' (Humphrey and Schmitz 2002: 1024). This 'chain-internal' reason for adopting a dynamic approach has been well documented (Lema 2010; Navas-Alemán 2011). However, there is also a 'chain-external' reason: the geography of the global market is changing rapidly. Markets of the rich countries are large but stagnant and markets of many poorer countries are small but growing rapidly. The big difference in growth margins matters. Global industry is restructuring as a result and the relationships between countries change rapidly. The global value chain framework helps to understand these changes in that it provides an analytical grip on private governance. Public governance also matters but it is not the focus of this paper.[1]

2.2 The wind power value chain

The main actors in the wind power chain are: (i) equipment manufacturers; (ii) component suppliers; (iii) planning, construction and logistics firms; (iv) consultancy and design services providers; (v) operation and maintenance services providers; and (vi) utility companies, independent project developers and financial investors (Frost and Sullivan 2010; CCB International 2011). For analytical purposes it helps to conceive of a two-pronged value chain: a manufacturing chain concerned with producing the key equipment and a deployment services chain concerned with all aspects related to deployment and utilisation (see Figure 2.1).

Figure 2.1 Basic wind industry value chain



Sources: Drawing on Frost and Sullivan (2010); EWEA (2007); EAI (n.d.); CCB International (2011). Arrows indicate flows of goods and services between functions in the chain.

This distinction takes into account that there are normally two lead firms involved in the process: wind turbine generator (WTG) assemblers in the manufacturing chain; and utilities or other types of project developers in the service chain. Value breakdowns vary a great deal (compare for instance Kirkegaard *et al.* 2009; BNEF 2010) but deployment activities account for a substantial share of value: Operation and Maintenance (O&M) alone account for around 20–30 per cent of project lifetime value.

There is, however, no strict division between the manufacturing and the deployment chains. Turbine manufacturers partake in the deployment services chain in various ways – usually in O&M in a two or three-year warranty period. Conversely, the owners or organisers often have power to influence relations in the manufacturing chain and demand particular components for the project turbines, although they sometimes complain that the WTGs guard their relationship with suppliers making these inaccessible to park operators (authors' interviews). The nature of the project and the location have an important influence on

[1] Berger *et al.* (2011) show how both private and public governance matter and argue that private and public governance approaches should be combined for further research in this area.

technological choices in the manufacturing chain such as turbine design and choice of components. However, as shall be discussed, there is a higher degree of turbine customisation in Europe as compared to China.

Utility companies are relatively immobile and tend to stay in or close to home markets, but this is also changing as they are beginning to develop a global outlook. Financial investors in wind power are more globally orientated. Wind park organisers work closely with turbine manufacturers as the turbine accounts for about 70 per cent of project construction costs and as the reliability of this equipment is normally key to the overall viability of the project.

Most of the discussion about the globalisation of the industry is concerned with the manufacturing chain and mainly with WTG manufacturers because these turbine firms have so far driven foreign direct investment flows and they compete head-to-head for market shares. These firms undertake the assembling of the turbine, which accounts for 20 per cent of the overall value-added (authors' interviews). They are called turbine 'manufacturers' although they are vertically integrated to different degrees with many components produced by external suppliers.

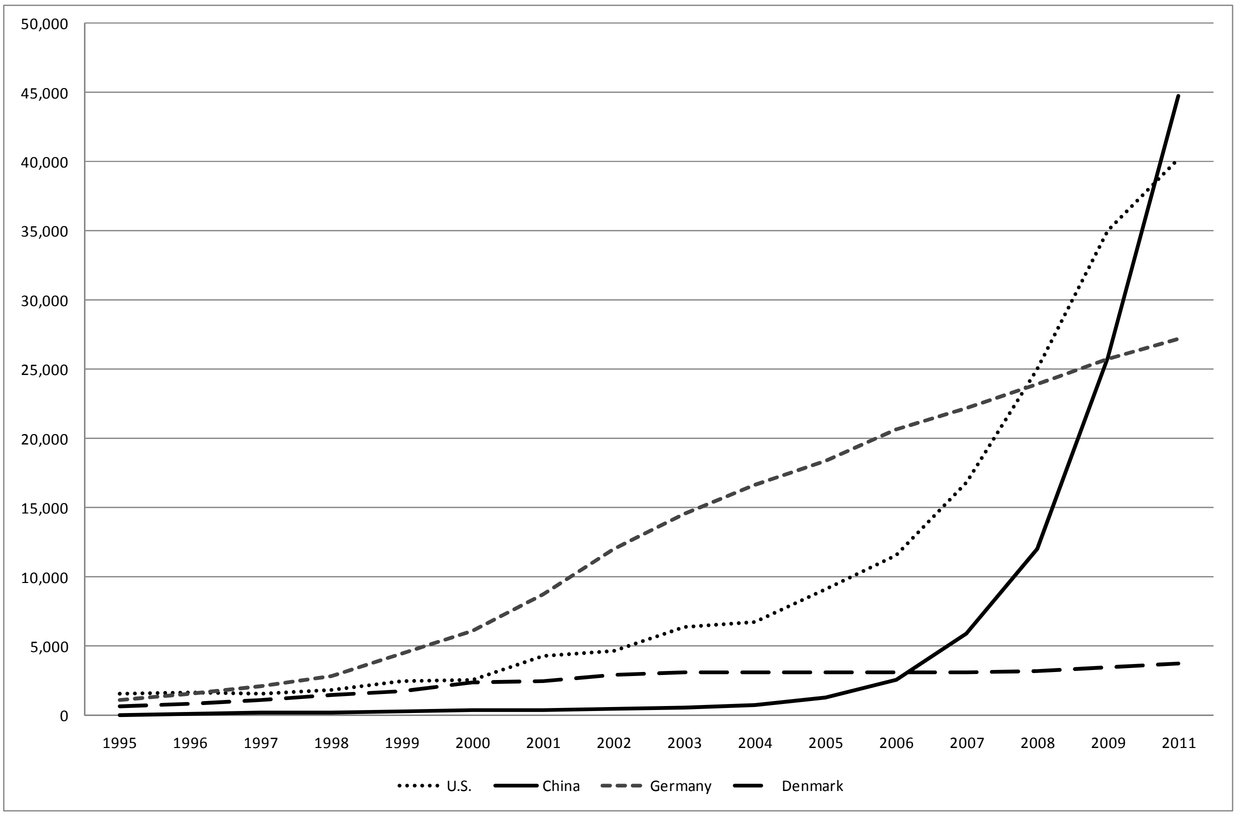
Key parts (in terms of cost) are towers, blades, gearboxes and power converters, but a turbine is made up of more than 8,000 different components. Many component suppliers have adopted follow-sourcing strategies: they situate themselves in close proximity to the overseas operations of turbine firms. Some of them have become truly global suppliers. Likewise, many of the service providers now operate globally.

We argue that we need to take into account the entire chain in order to understand relationships between Europe and China. We also argue that distinguishing between the manufacturing and the deployment chain is helpful because most activities in the former are geographically more mobile than in the latter. This matters because the geography of global markets is changing.

Global demand for wind power is growing in absolute terms but this market expansion is highly uneven between regions and countries. The combined installed capacity of the EU countries still exceeds the capacity in North America and Asia. However, as Figure 2.2 shows, the growth in demand now comes largely from the USA and China. These markets now exceed (by far) the installed capacity of any country in Europe, including Europe's top installer, Germany, where growth in demand has slowed down in recent years. This means that on the one hand, Europe has created the pioneering firms in the industry and created clusters of accumulated skills and capabilities. On the other hand, the key national growth markets have now shifted out of Europe. This is causing significant global transformations in the business landscape as well as restructuring of international linkages. However, the extent and depth of these changes depends to a considerable extent on the geographical mobility of activities in the manufacturing and deployment chain – elaborated in Section 3.

The sections that follow present the detailed empirical analysis. They are based on the usual secondary sources (academic and business literature) and on fieldwork conducted in the second half of 2010 in Germany, Denmark and China. In these countries, we conducted a total of 30 key informant interviews with policymakers and government institutions, research institutions, business associations and NGO support organisations, utilities companies, turbine manufacturers and components suppliers. These interviews were arranged as semi-formal discussions guided by a questionnaire template. Whenever possible, we conducted joint interviews in the three different countries. With members of the research team coming from Denmark, Germany and China and interviews being conducted with different types of actors, it was possible to see the different perspectives on the key issues. Seeing the issues through the different national lenses and business function lenses is essential for making a judgement on the current practices and future prospects of cooperation, competition and conflict between China and Europe.

Figure 2.2 Cumulative installed wind power capacity, 1995–2011 (MW)



Sources: Earth Policy Institute (2010) and WWEA (2011).

3 Changing lead markets

This section shows how lead markets are changing on a global scale: growth in European home markets is slowing down, in particular in Denmark and Germany, but these two countries remain strong on the production side of wind power technology. Despite increasing global competition, these countries still host leading global producers and service providers. Meanwhile, the market is shifting to China, where heavy state investments drive up demand. This has created strong domestic players that are now visible on the world stage.

3.1 Europe: The traditional leader

Europe is the traditional leader in the wind power industry. As a whole, the European Union has the most developed market for wind energy worldwide with a total accumulated deployment of 84 GW – equivalent to 44 per cent of globally installed capacity – at the end of 2010. Combined, the six largest EU countries alone accounted for 68 GW total installed capacity (Table 3.1), more than either China (44 GW) or USA (40 GW) (GWEC 2011).

Wind power is central to the ambitions of political leaders in the EU of developing strong green economies. EU leaders have set a binding target to supply 20 per cent of its total energy consumption from renewable sources by 2020, with wind power being an important element (EurActive 2010). Each member country has a legally binding target for wind power generation in 2020. These targets specify that wind energy should reach at least 213 GW of combined installed capacity in 2020 (EWEA 2011). However, so far there has been an unequal distribution between EU countries. Most EU 27[2] countries have no wind manufacturing industry although interest in wind power as a source of electricity is increasing.[3]

Table 3.1 Total installed capacity and added capacity in 2010

	Total capacity 2010 (MW)	Added capacity 2010 (MW)	Growth rate 2010 (%)
EU6*	68,285.80	6,535.00	15.57**
Germany	27,215.00	1,551.00	6.00
Denmark	3,734.00	309.00	8.90
China	44,733.00	18,928.00	73.30

Source: GWEC (2011). Notes: * EU6 are the six EU countries in the global top ten in terms of installed capacity: Germany, Spain, Italy, France, UK, Denmark. ** Average EU6 growth rate.

Denmark and Germany are the pioneering countries in Europe with the most developed markets. Leadership in the two countries has traditionally stemmed from both the size of home markets (demand) and production capacity for catering for these markets (supply). Today the demand side of this formula is weakening. Although both countries have very high wind shares in the electricity mix – Denmark has 21 per cent and Germany 9 per cent – both countries have had relatively low growth rates compared to other EU countries, let alone China. With high 'saturation levels' in these markets, Denmark achieved a growth rate of 8.9 per cent while Germany achieved 6 per cent in 2010 (Table 3.1). Many new turbines were installed offshore, particularly in Denmark where these accounted for 62 per cent of the turbines installed in Denmark in 2010.

3.2 The challenge from Asia

On the supply side, European enterprises are still dominating global market shares, but they are steadily losing their traditionally very strong position as Asian – Chinese and Indian – companies are entering the industry. A decade ago, all of the top ten firms in the world were European. In 2003, eight were European and by 2010, only four of the top ten wind turbine manufacturers had their headquarters in Europe (Table 3.2). The European dominance has been broken by China and India.

Most of the competition with foreign firms takes place outside Europe in new growth markets. European firms have invested notably in the USA and China. The European turbine producers have (re)located production capacity to where there is market demand. While European manufacturers in 2008 sold more than 60 per cent of their turbines outside their home markets, Vestas, Siemens and Nordex all had overseas sales shares of roughly 95 per cent. By contrast, as shall be discussed, Chinese manufacturers were almost exclusively focused on their domestic markets (see also Kirkegaard *et al.* 2009: 44). The challenge for European producers is to supply products and services that are competitive in the global market. In section 4, we discuss why Denmark and Germany are in a strong position to do

2 The 27 member countries of the European Union.

3 In terms of new installations, many Western EU countries are showing stagnation, whereas there is strong growth in a number of Eastern EU countries (WWEA 2011).

so. However, it remains a crucial point that the continued strong position of Europeans firms will depend on state support for wind power which can match that of China.

Table 3.2 Global top ten turbine manufacturers 2003 and 2010 (world market shares)

2003			2010		
Origin	**Firm**	**Share**	**Origin**	**Firm**	**Share**
EU	Vestas (DK)	21.80%	EU	Vestas (DK)	14.80%
US	GE Wind	18.00%	CN	Sinovel	11.10%
EU	Enercon (DE)	14.60%	US	GE Wind Energy	9.60%
EU	Gamesa (ES)	11.50%	CN	Goldwind	9.50%
EU	NEG Micon (DK)	10.30%	EU	Enercon (DE)	7.20%
EU	Bonus (DK)	6.60%	IN	Suzlon	6.90%
EU	REpower (DE)	3.50%	CN	Dongfang Electric	6.70%
EU	Nordex (DE)	2.90%	EU	Gamesa (ES)	6.60%
EU	Made (ES)	2.90%	EU	Siemens Wind Power (DK)	5.90%
JP	Mitsubishi	2.60%	CN	United Power	4.20%
	Others	5.30%		Others	17.5%

Source: BTM (2004; 2011). The locations of headquarters of European firms are noted in brackets.

3.3 China's rise in wind power

Chinese state officials have repeatedly stated that the strengthening of technological capabilities in green industries is crucial to the ambition of transforming China from a developing country competing on low wages to a developed economy competing on high value-added technologies (Ford 2009). The commitment to green technology was apparent in the Chinese response to the recent crisis in the global economy and in the newly released twelfth five-year plan. The nature of this response suggests that China is committed to leading the way in low carbon development.[4] Nowhere is this more evident than in the case of wind power.

In 2010 China became number one globally in total installed wind power capacity. During 2010 China added almost 19 GW wind power capacity to its existing wind power installations (Table 3.1). This means that China accounted for more than 50 per cent of the world market for new wind turbines in 2010 (WWEA 2011: 5). It is planning to reach a total wind power capacity of 150 GW in 2020 of which 138 GW should be built as part of seven geographical 'wind power bases' larger than 10 GW each (Junfeng and Hu 2007: 24). This official target is lower than that of the EU (213 GW) but current Chinese growth rates – 73 per cent in 2010 – suggest that China may well have overtaken the EU by 2020. This will make China the unrivalled growth market in the years to come.[5]

The next section 4 on the European wind power industry and the following section 5 on China have as their main purpose to show how the markets and value chains are organised

[4] The nature of China's response suggests that it is committed not only to develop green technology domestically, but also to lead the way in low carbon development on the global scene. In 2008 and 2009, the stimuli packages in China were the most ambitious in the world in terms of supporting green investments. It invested 5.3 per cent of GDP in green technology compared to less than 1 per cent for the United States in 2008.

5 However, by some estimates, the current official Chinese targets for 2020 mean that wind power will account for only 3 per cent of the electricity output at that time (Delman 2009).

and how they are changing on a global scale. The final section 6 then pulls it all together, drawing out what it all means for the relationships between Europe and China.

4 The wind energy industry in Denmark and Germany

This section focuses on the key actors in the wind power chain in Denmark and Germany with the aim of showing how the European value chains are organised and what this means for global competitiveness. European leadership in this industry stems from highly developed value chains, with strong capabilities in both manufacturing and deployment. Both the value chains and the institutional systems are being shaped in such a way that they increase the performance of wind power. This creates European solutions of high quality but also of high costs. The challenge is to reinvigorate the European wind power innovation systems in a situation in which lead markets are moving away from Europe.

4.1 The manufacturing chain

The Danish and German wind turbine industry started to develop in the 1970s and 1980s mainly because of an environmental grassroots movement. Until the 1990s, the industry structure was very much shaped by the wind turbine producers that grew out of this movement. A first major wave of mergers and acquisitions led to the consolidation in the wind turbine industry in Denmark and Germany (Table 3.2). Only two of the original pioneers, Vestas and Enercon, have been able to turn their first mover advantage into technological strength and large-scale production. After the turn of the millennium, a number of smaller wind turbine producers were bought up by established wind firms or by large industrial conglomerates looking for an entry into the fast growing renewable energy industry. As seen in Table 4.1, many of the European firms have become global, serving an increasing number of markets across the globe. Indeed, a notable feature of the European wind turbine industry is its internationalisation in terms of markets served and to some extent also its ownership.

Denmark’s prominence in the wind turbine industry is largely due to Vestas, the global market leader with almost 25,000 people on the global payroll. Siemens Wind Power (formerly Bonus Energy) is headquartered in Denmark and has become an important player in the global industry too. These firms compete to supply new projects in their home market, but they predominantly compete in foreign markets. However, they also collaborate closely in Danish cross-organisational policy and research initiatives.

Table 4.1 Top European turbine generator firms (2009)

Firm	Global market share 2009	No. Markets 2010	HQ Country	Ownership	First turbine
Vestas	12.50%	25+	Denmark	Denmark*	1979
Enercon	8.50%	15+	Germany	Germany	1984
Gamesa	6.70%	10+	Spain	Spain	1994
Siemens Wind Power	5.90%	10+	Denmark	Germany	1980
REpower	3.40%	10+	Germany	India	2001
Total	37%				

Source: BTM (2011); company data.* Note: the majority of Vestas shares are owned by investors from outside Denmark. European turbine firms in global top ten, based on worldwide market shares.

The German wind turbine industry is dominated by Enercon (Molly 2010). Notwithstanding an overseas revenue share of around 60 per cent, Enercon is mainly focused on the European market and has, in fact, been downsizing its presence in the market outside Europe (Hein 2010; authors' interviews). Enercon has a high degree of internal manufacturing due to its distinct direct drive technology (no gearbox). Other German and European wind turbine producers (with the exception of the offshore specialist Bard) focus more on assembling and less on in-house manufacturing.

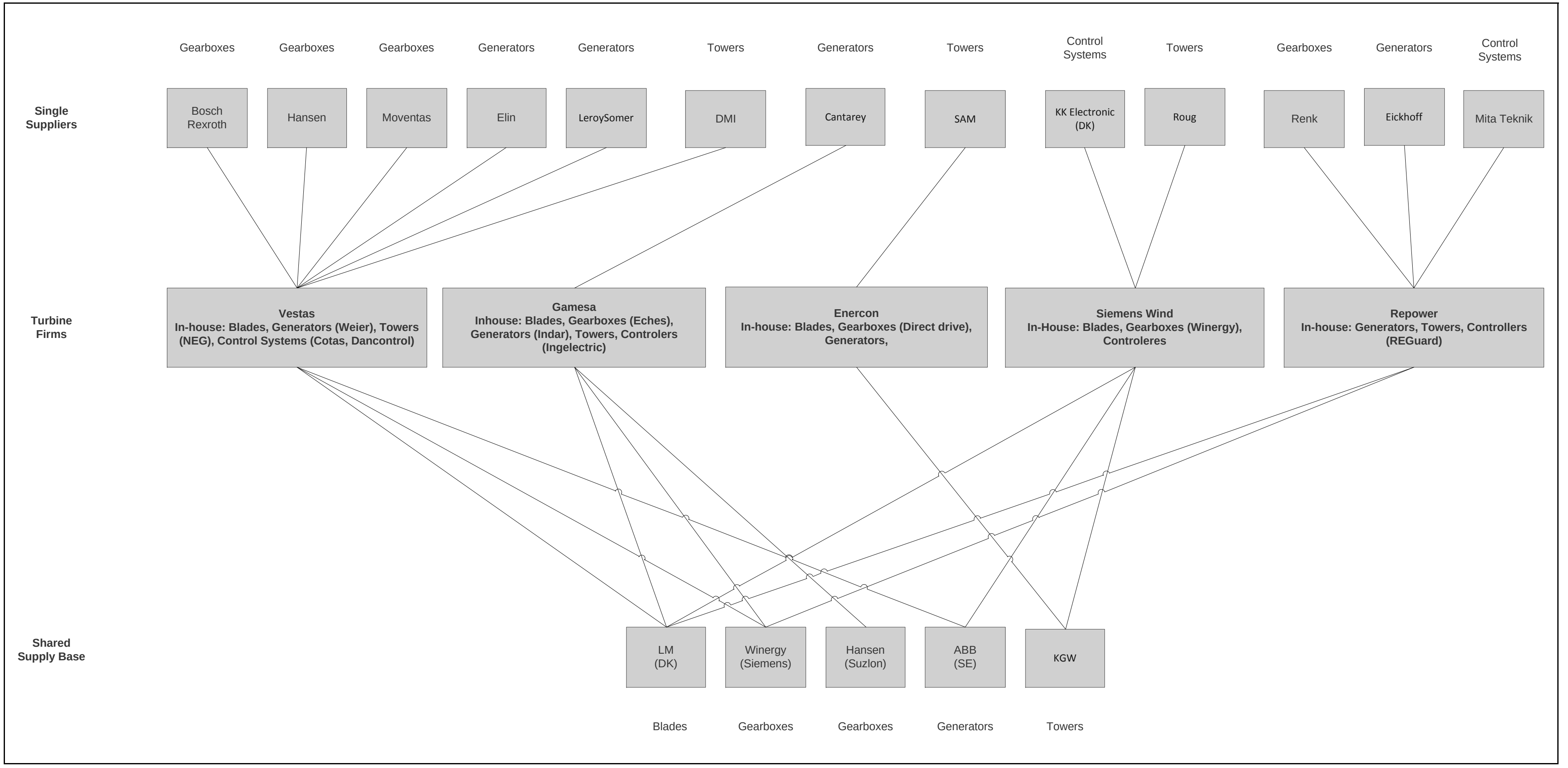
The European lead firms all have a high degree of vertical integration with many components being produced in-house (Figure 4.1). Around 50 per cent or more of an average Vestas turbine is produced in-house (in terms of production costs). The value chain structure is a function of close attention to productivity and reliability of the turbine and of turbine designs that have been carefully developed over more than 30 years. This also means that the manufacturing value chain of the German and Danish wind turbine industry is defined by a complex and mutually dependent relationship between turbine producers and a network of component suppliers.

The combination of technological complexity of modern wind turbines as well as high durability requirements result in a relationship of lead firms and component suppliers that may best be captured by the concept of *relational* value chain (Gereffi *et al.* 2005). What we mean by this is that the lead firm and supplier exchange vast amounts of information for specifying and testing the components in the course of design and prototype testing. It also means that these lead firms work with a relatively small number of highly competent key suppliers. Some of these are global suppliers in what now constitutes a relatively small 'shared supply base' consisting of world class firms who can provide components in all the key growth markets.

Compared to China, there is a relatively low degree of price competition among suppliers. This is due to the traditional structure of the European wind turbine industry which is based on specialised medium-sized companies. In contrast to other industries where large conglomerates are the industry leader, wind turbine manufacturers have focused less on strategic supply chain management to drive down costs (Hohrath *et al.* 2010; authors' interview). Usually, components have to be customised for each individual lead firm and often for each individual project. In some cases, turbines are built bespoke to a particular order related to a particular wind farm development. This created a need for collaboration across the value chain. Similarly, such collaboration occurs on a regular basis in the continuing race to develop bigger turbines with a higher megawatt electricity capacity. Buyer-supplier relationships are therefore typically longstanding and switching costs – the costs for the turbine manufacturer involved in replacing one supplier with another – are considerable because suppliers have accumulated knowledge about lead firm products and processes. Suppliers often design components such as gearboxes, generators and power electronics to the specifications provided by the turbine firm.

As shall be discussed, the drive towards modular product architectures and networks is weaker than in China because European firms put more emphasis on continuously tweaking solutions for increased reliability, resulting in organically developing and more dissimilar and more expensive but higher quality designs. One of the main reasons for this orientation lies in incentive structures linked to output performance. Wind energy support mechanisms in Europe such as feed-in tariffs and market premium systems provide strong incentives to maximise the cost effectiveness of the power production, enhance demand-side management and improve the stability of the transmission system. In general, mechanisms are on an electricity generation basis, not a capacity installed basis. This has lent emphasis to turbine reliability and effectiveness and has extended the focus from the manufacturing to the deployment chain.

Figure 4.1 Top five European turbine manufacturers and key component suppliers



Source: EWEA (2007) using data from BTM; note that many of the firms listed as single suppliers also supply to other turbine firms outside the top five. Note that these are the key suppliers. There may be other suppliers to these top five firms in different markets.

4.2 The deployment chain

This subsection continues with the value chain analysis of the Danish and German industries but shifts the focus to the deployment chain. It identifies the key actors and segments before discussing directly the insights that are relevant to our question of international competition in the industry.

The actors that are most important in the deployment chain are utilities such as DONG in Denmark and RWE, E.ON and ENBW in Germany. Coordination of the deployment chain has shifted away from manufacturers to utility companies as: (i) power producers have come under pressure to incorporate renewable energy in their portfolios; (ii) investment requirements have increased; (iii) the value chains have become more complex; and (iv) pricing models have increased uncertainty. This process started in the offshore market first but is also increasing in the onshore market.

The utility companies play the role of 'lead firms' by bringing together and coordinating the various actors from the deployment and manufacturing chains, including consumers, transmission system operators, turbine manufacturers, logistics and construction firms, knowledge intensive business services and specialised suppliers. They have also been important in defining and enforcing stricter industry standards.

It is widely agreed that one of the key strengths of Denmark and Germany is that they have highly developed value chains involving the full range of private sector deployment actors as well as supporting public agencies in the wind power innovation system (Andersen and Drejer 2008; Smit *et al.* 2007; Sovacool *et al.* 2008; Hoffmann 2005). In the case of Denmark, examples of these actors – beyond utility firms – are shown in Table 4.2.

Table 4.2 Examples of Danish firms in deployment

Functions	Firms
Consulting and certifications organisations	Cowi, DHI, Difko, Garrad Hassan
Finance and insurance	Atradious, Difko, Deloite Sølyst
Transportation and installation	A2Sea, Baltship, Deugro, Liftra
Consultancy services	Rambol Wind, Cowi, Grontmij-Carl Bro, Garrad Hassan
Maintenance	Dan Service Wind, Danrun Windservice , DMP, Nordic Offshore

Source: Authors' own.

The deployment service segment is arguably becoming more important as the sector drives towards offshore projects. While there are also variations in turbine technology, the big difference between the onshore and offshore markets lies in deployment. This is important because Danish and German companies are leading in the offshore market.

Denmark is dominant in the offshore segment: 90 per cent of the world's offshore wind turbines are either Danish produced or have Danish developed foundations and components and have often relied on a range of Danish support services. Siemens and Vestas accounted for 54 per cent and 34 per cent of the market share of totally installed offshore capacity at the end of 2009. By contrast, the current offshore share of non-European firms is negligible. Sinovel (3 per cent) and GE Wind (1.7 per cent) are the only non-European manufacturers who have already installed offshore wind turbines (own calculation based on BTM Consult (2010: 21). With a slight delay, German utility firms such as RWE and E.ON as well as turbine manufacturers such as REpower and BARD have also become active in the offshore segment.

For offshore wind parks, upfront fixed capital costs make up 70 per cent of lifetime costs. Roughly, half of that are service expenses – design, foundations, installations and grid connection – and the other half is the cost of the turbine. The variable costs – O&M – constitute 30 per cent of lifetime costs (DEA 2005). The costs of deployment services are higher in the offshore wind sector because of the greater difficulty in installing and maintaining the parks.

Overall, the deployment chain is important in terms of jobs and revenues. According to Anderson and Drejer (2006), only 41 per cent of the firms in the Danish wind energy industry are classified as manufacturing firms. As seen in Table 4.3, employment in the deployment chain – process and quality assurance, service and maintenance, sales, etc. – constitutes almost 40 per cent of total wind power jobs in Denmark. Another 10 per cent of employees work in product development and testing. Hence, services constitute roughly 50 per cent of direct wind power employment in Denmark, while manufacturing accounts for the remainder. This is a larger than average share of service employment in the European turbine industry where services account for 40 per cent, including R&D activities (Blanco and Rodrigues 2009). While detailed data is not available, it is also thought to be considerably higher than in China.

Table 4.3 Danish direct wind power employment classified by job type

Job classification	**Share (per cent)**
Production	51
Service and maintenance	11
Testing and development of new products	11
Process and quality assurance	10
Sales and marketing	10
Other	7
	100

Source: DWIA (2011).

The regulatory environment puts considerable pressure on actors in the deployment chain, notably utility companies. From the outset, the focus in Europe is not on installed capacity *per se* but on generation of consumed electricity. This means the deployment chain is forced to be highly developed to increase effectiveness and efficiency. Adaptation of regulatory environments – for instance, the shift from a traditional feed-in tariff to a premium price model in Denmark, and now also in Germany – has created incentives for improving the reliability and performance of wind parks. Interestingly, utility organisations are now not only investing in wind power projects but also substantially in R&D to drive down the costs of operation across the entire value chain.

In section 2, we emphasised that it is important to take into account the entire chain, not just manufacturing production. One reason is that there is much less globalisation in deployment than in manufacturing. Proximity is a major factor in the deployment chain. This provides a degree of 'natural protection', rendering this part of the chain less footloose.[6] What this means is that employment in these areas will remain bound to the local area of wind power investments. They cannot be offshored because these functions are impossible to trade

[6] A footloose industry or business function is one whose location is not influenced strongly by access either to materials or markets, and which can therefore operate within a very wide range of locations.

across distance. While these elements can be globalised through foreign direct investment, this type of globalisation has so far been negligible in most parts of the deployment chain.

Yet certain deployment functions have a degree of mobility. Many utilities have adopted an international outlook. For example, Danish DONG and German RWE are operating in wind power across Europe. However, although German E.ON has even penetrated the US market, there is much more European regionalisation than globalisation in this sector. There are no available comparable statistics on the relative globalisation of utility companies, but our interviews unearthed little cross-continental globalisation in the utility segment. Compared to other industries in the world economy, FDI is heavily constrained in the electricity sector. The generation and distribution of electricity remains highly restricted in most countries and has seen only a moderate easing (Golub 2009). German O&M firms are seeking to leverage their accumulated capabilities by expanding abroad, but mainly within Europe (Daubney 2011). Many of these actors are likely to operate much more globally in the future by setting up foreign subsidiaries in new growth markets.

4.3 Globalisation and the location of innovation

There is consensus among the European stakeholders that the route to continued success lies in boosting the wind power innovation systems in which the key enterprises are embedded. However, this might become increasingly challenging.
The main problem is the increasing geographical disconnect between the European innovation system and new growth markets. The slowing down of public investments in wind power means that much of the original dynamism, which was created by close interactions between users and producers of wind power technology, is now waning. There is support for backing the supply side of the innovation system, but large-scale deployment requires huge financial investment. Financial and political problems in deployment are slowing down the growth of the European market.

So far, Denmark and Germany have had success in creating supply-side hubs. The public authorities have supported this process by giving support for R&D in research institutes such as Risø, for collective R&D projects spanning many different stakeholders, by establishing test sites and by using their convening power to bring together the key industry stakeholders. The leading firms also continue to make considerable R&D investment in Europe. Siemens has decided to expand its research activities in Denmark and expects to create thousands of high-skilled jobs. This investment, aimed at boosting activities relevant for the European offshore market, could become relevant for competing globally. Similarly, Gamesa and Suzlon have set up subsidiaries in both Denmark and Germany to gain access to sub-suppliers and be close to where the standards are set. Nevertheless, the question is whether in future these firms will continue to locate research and innovation in Europe when production and use expand more rapidly elsewhere.

Interviewees indicated that business logic rather than company nationality will determine the location of innovation activities.[7] For the time being, Europe retains strong supply-side advantages. Danish and German turbine producers maintain very close linkages to leading competence clusters in Europe (Sovacool *et al.* 2008). Their R&D headquarters are mainly located in Denmark and Germany respectively, mainly Aarhus in Denmark (Rasmussen *et al.* 2010) and Bremerhaven in Germany (Knight 2011). These locations provide proximity to advanced test sites and technology organisations, including technical institutes and universities, and ports. In the meantime, China is establishing its own test sites and increasing R&D investments.

[7] The high degree of overseas engagement raises the question of whether European turbine firms align with European interests. To certain observers this is very clear. For instance, a leading Danish observer has stated that Vestas is no longer a Danish firm driven by Danish interests (Lunde 2010). People and financial institutions from outside Denmark now own the majority of the Vestas shares.

The competitive advantage in Denmark and Germany derives from long histories of technological learning and accumulated capabilities. Relationships have been built over time in an innovation system that is characterised by a fine division of labour between lead firms, specialised suppliers and research institutions. Interviewees stated that even though these firms are inserted into multiple national innovation systems, the linkage within and back to the ‘mother clusters’ is likely to remain important at least in the near future (see also Andersen 2006). European connections will depend on continued investment in wind power installation and in R&D. In the longer run, industry stakeholders agree that the European clusters cannot specialise and lead in all aspects of wind technology, but there is less agreement on the particular areas in which these clusters should focus.

5 The wind energy industry in China

In this section, we start by examining the key characteristics of Chinese wind value chains. We then focus on inward globalisation (European firms in China), outward globalisation (Chinese firms in Europe and third markets) and the technological capabilities of the leading manufacturing firms. The section shows that there are key differences between China and Europe. These differences have implications for current and prospective Sino-European relationships in the sector, which are examined in section 6. But first we need to understand the case of China itself. This is done in some detail in this section because China is the main driver of change in the global wind industry.

5.1 The Chinese value chain – manufacturing

Due to the large Chinese market, Chinese turbine firms have acquired substantial global market shares. In 2009, Sinovel ranked third in the world (9.2 per cent), Goldwind fifth (7.2 per cent) and Dongfang seventh (6.5 per cent). These three big firms – shown in Table 5.1 – dominate the market. They had a combined global market share of 22.9 per cent in 2009. There are also a number of other interesting players with high potential such as SE Wind (Shanghai Electric) and private-owned enterprises such as A-Power, Envision and Min Yang.

One of the reasons why the Chinese turbine industry has been able to grow so fast is that firms have grown out of other segments of the diverse industrial base, particularly heavy industry. The leading firms emerged out of large heavy machinery manufacturers and utility firms that had capability in key fields related to manufacturing as well as large-scale project management for deployment.

The offshore segment in China is planned and projected to increase rapidly in the future, but currently only a small share of the growth of the leading champion firms comes from offshore wind park projects. As mentioned, these are technologically and logistically more demanding compared to onshore wind parks. To enhance technology development, state-led offshore concession projects (which are still being developed) specified that locally produced 3 MW turbines should be used (GWEC 2010: 27). All the big Chinese firms can deliver such turbines while the leading European manufacturers do not produce 3 MW turbines in China.

Compared to European manufacturers, the Chinese lead firms are vertically disintegrated, with relatively few components manufactured in-house. With regard to the supply base, a broad network of Chinese suppliers has emerged which are able to produce components on a large scale in China, like blades (e.g. Tianjin Dongqi Wind Blade Engineering), bearings (e.g. Zhejiang Tianma Bearing Co.), transmission (China Transmission), towers (e.g. Qingdao Wuxiao Group), gearboxes (China High speed transmission group). Some four years ago the Chinese wind turbine manufacturers were almost entirely dependent on the import of bearings and electronic controls (Junfeng and Hu 2007: 17), a situation that changed due to increasing investments in this segment (Schwartz and Hodum 2008). Now there are many options for all key components such as for controllers, power electronics, gearboxes and so forth (Meyer 2010). This means that there are now numerous suppliers of each component. In addition, an analysis of the relationships between domestic turbine firms and key component suppliers shows a very high degree of supply base sharing (Figure 5.1).

Table 5.1 Leading Chinese firms (in global top ten, based on worldwide market share)

Firm	Global market share	No. markets 2009–11	HQ	Ownership	First turbine shipped
Sinovel	9.2%	3	Beijing	Government-owned; listed	2004
Goldwind	7.2%	3	Xingjian	Government-owned; listed	2001
Dongfang Electric	6.5%	2	Chengdu	Government-owned; not listed	2004

Source: BTM (2010); Company data.

Depending on turbine type and size, 70 to 90 per cent of a turbine assembly can be met by domestic components, but some high-tech components are provided by global suppliers in China or suppliers in Europe or the USA. Firms such as Goldwind and Sinovel tend to sign long-term cooperation agreements with firms such as LM, Windtec and Mita Teknik. As shall be discussed, the similarity in Chinese turbine designs (partly arising from design licensing) arguably makes supply-base sharing easier which, in turn, increases the economies of scale of the industry. There is a complete Chinese supply chain and some components such as blades and gearboxes are already being exported (BTM 2008).

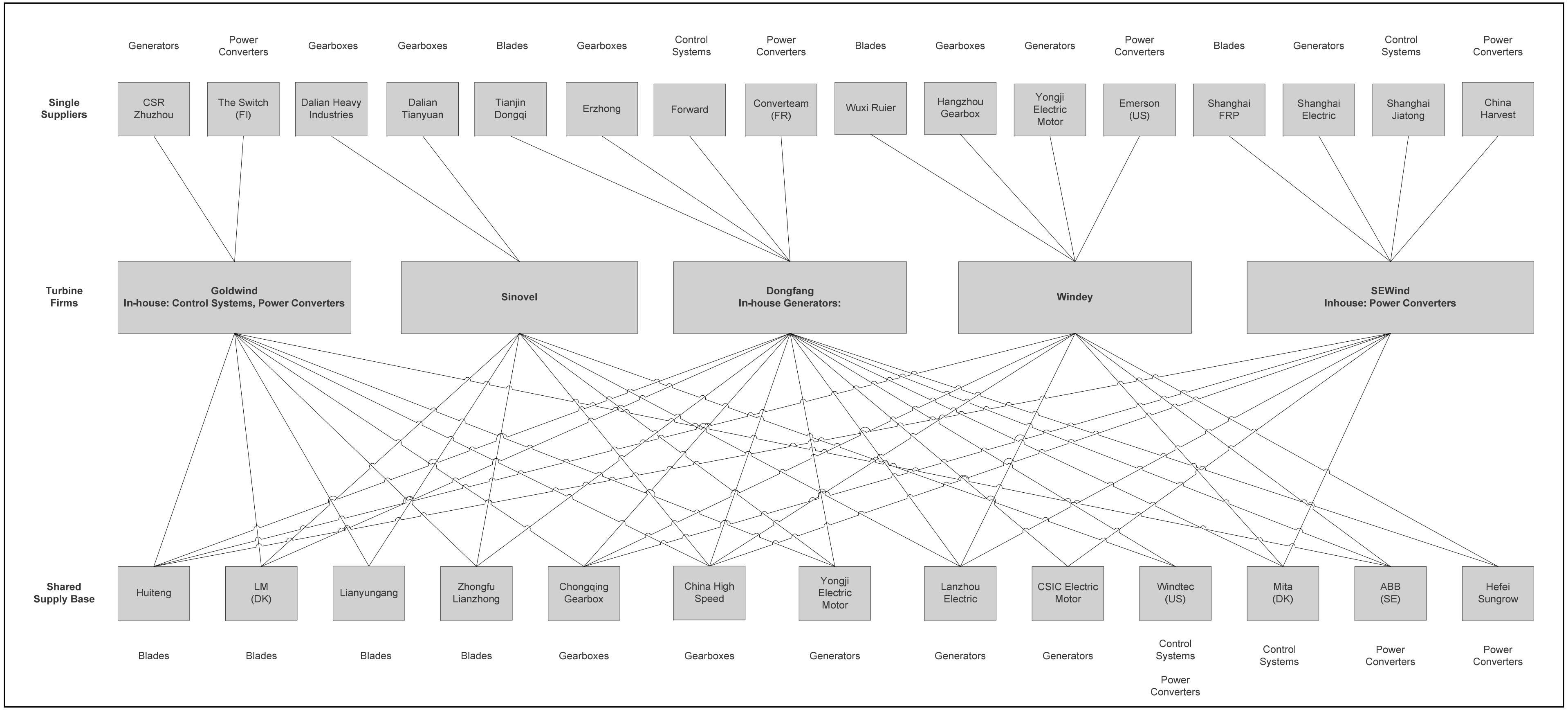
Chinese components can bring down production costs of turbines – foreign turbines tend to cost 20 per cent more than those manufactured by Chinese firms (BTM 2008: 19)[8] – but many observers agree that Chinese companies can rarely compete with foreign, particularly European, competitors, with regard to adaptability (design skills for turbine customisation) and reliability. In many new growth markets, however, European firms may find it difficult to compete, because most attention is paid to price.

Compared to Europe, the competitiveness of the Chinese industry depends not only on individual firms but also significantly on the entire value chain. The supply chain relations described here constitute a ‘Chinese model’ of industrial organisation in the wind power industry that may prove highly competitive in many market segments at home and abroad.[9] In terms of value chain management the Chinese wind turbine industry thus already resembles the *modular* value chain structure (Gereffi *et al.* 2005). Modularity has two main sources. First, turbines have tended to be based on European licences for ‘mature’ turbines that were a few years behind the technology curve. This made it easier to create markets for standardised components. Second, there has been a lesser degree of customisation of turbines for particular products. This has been related to the narrower policy-focus on installed capacity rather than actual electricity generation effectiveness. In general, Chinese firms have had a smaller range of different turbine models, compared to their European rivals. A large base of shared suppliers has been able to produce the needed components. This has been a major reason for the enormous speed at which turbines could be installed

8 While large Chinese wind turbine manufacturers benefited greatly from preferential policies adopted on various levels of governance, the crowding out of European manufacturers is also explained by substantial differences in prices of turbines. In 2006 when the domestic segment took off, the turbines were typically priced 15–20 per cent lower than their foreign counterparts. By 2010, the price gap had increased to more than 27 per cent (BNEF 2010: 9).

9 Mai Fujita identified a distinct Chinese arm’s length form of industrial organisation in the motorcycle industry. While developed at home, this model was transplanted to Vietnam by Chinese firms operating in that market (Fujita 2010).

Figure 5.1 Top five Chinese turbine manufacturers and key component suppliers



Source: Data from BTM (2008).

without running into the problem of component shortages. The ‘Chinese model’ may have important competitive advantages arising in particular from organisational flexibility and external economies of scale, advantages that go beyond labour costs. Chinese firms may therefore be able to compete abroad without locating all elements of production in China.

5.2 The Chinese value chain – deployment

Information about the Chinese deployment chain – wind power services – is scarce compared to manufacturing, but interviews and press reports give us important insights about actors and capabilities in the chain. There are at least 30 companies – including the five largest utility firms – that build wind farms in China. The dominant actors are subsidiaries of state-owned power generation firms, including the three largest, Longyuan, Datang Corp Renewable and Huaneng Renewables. These firms are state owned but have listed substantial shares of their wind business on stock markets – in the region of 30 per cent of the companies – in order to raise cash for investments. Two other types of firms also operate in the segment. The first are energy firms that do not focus primarily on electricity, including China National Offshore Oil Corporation (CNOOC) and China Hydro. The second are independent power producers (IPP) and institutional investors, some of which are foreign. These include firms such as British Honiton and German Infrawest.[10] However, interviewees indicated that there are still substantial legal constraints for private investments in this sector.

Pre-deployment activities are coordinated by project developers. Activities such as site assessment are carried out by independent suppliers hired by the project developers. There are independent firms such as Xinjiang Windpower Engineering Design and Consultation that operate in this area, providing park design services but core site assessment services are typically provided by public research institutes. These institutes are classified according to competencies and only selected institutes are authorised to engage in project assessment and design activities for national tender projects (as opposed to regional ones). Problems with wind site assessment include inadequate data about wind resources and micro-siting (exact positions of the individual turbines). In China, the average deviation between expected and realised electricity production is high (BTM 2008).

In recent years the deployment part of the chain has become increasingly competitive in China. Each province tended to have its own construction firms, but in recent years, there have emerged a number of national players such as Shenyang Power Group. The national government allows foreign construction firms to compete in the area, but provinces tend to favour locally owned firms. The offshore market may become particularly open to foreign firms because established offshore construction companies and logistics firms (such as Danish A2SEA) may be needed when the offshore wind markets develop (BTM 2008). The same is the case with O&M more generally. One important element in this respect, which is not provided by Chinese firms, is implementation of condition monitoring systems (CMS). German 8.2 Consulting has developed software that can analyse CMS data and this software is now used in the Shanghai Donghai Bridge offshore wind farm (Daubney 2011).

O&M is often carried out by the turbine manufacturers. The leading firms such as Sinovel, Goldwind and Dongfang all have their own O&M teams, which they deploy for a warranty period, and sometimes beyond the warranty period for a fee. However, in contrast to Europe, the leading farm owners and operators such as Longyuan and Datang typically undertake O&M with in-house resources. The problem is that the engineers conducting O&M in China rarely have sufficient training (authors’ interviews). Smaller park owners can draw on specialised services firms such as China WindPower Group which has established a number of WindPower Express O&M Centres in resource-rich wind power regions to cater for a

10 In the future, China may also see investment from non-traditional investors. IKEA states that it is interested in investing in China where much of its manufacturing capacity is based. Such investment, including investment in grids, could allow the firm to advertise the newly emerging ‘Wind Made’ standard logo on many of its products (Quilter 2011).

number of parks in the area. According to BTM (2008), the Chinese market for independent O&M firms is still constrained by the farm operators' unwillingness to pay, but China is expected to become the largest wind power O&M market by 2016.

Observers agree that the weakest links in the Chinese value chains are in the deployment chain. Across the board, there are problems with site assessment, O&M in which operators do not have sufficient skills, and grid integration which cannot keep up with the speed of wind park completions and is prone to big curtailment problems. These problems arise both onshore and offshore, but particularly in the offshore segment where Chinese firms have little experience. These 'soft spots' lead many observers to believe that the Chinese industry is performing at a sub-optimal level, for instance in terms of utilisation compared to the EU (Conrad and Meissner 2011). There is agreement that the focus of the industry has so far been to achieve large installed capacity. There is also agreement, however, that the focus is now shifting from quantity to quality and operating performance. This is evident in the shift in criteria for concession projects from installed capacity to output performance. The main challenge in China is to shift the emphasis from products to systems. This is more difficult than developing in-house technological capabilities at the firm level. It depends on building open systems and developing new modes of governance.

5.3 European firms in China

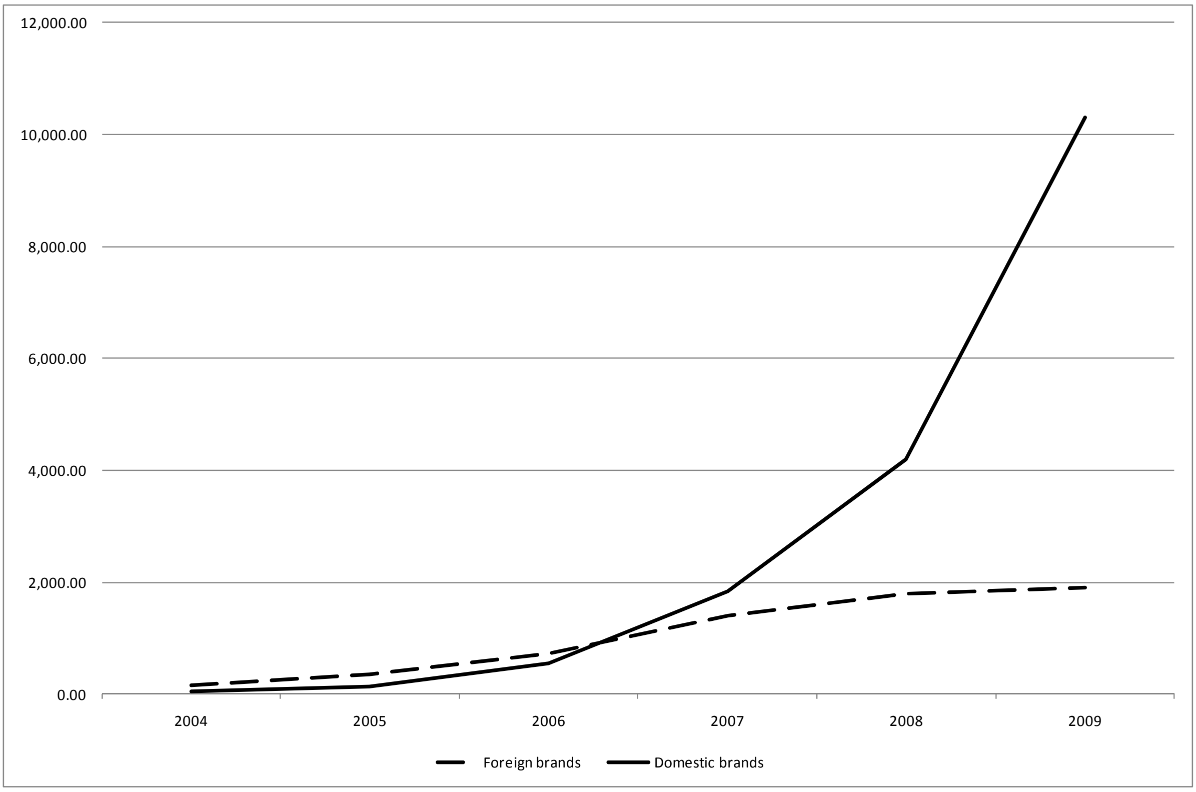
Until 2005, the Chinese wind power market was largely dependent on foreign technology produced by subsidiaries of European turbine manufacturers. These firms accounted for 70 per cent of the Chinese market in 2005. Procurement practices and the local content requirement (in operation between 2004 and 2009) meant that within half a decade China managed to build up a national turbine manufacturing industry that now delivers 85 per cent of the turbines erected in China in 2009 (Junfeng *et al.* 2010: 37). The shift in market sales between local and foreign producers is displayed in Figure 5.2.

China has a dual market made up of big national projects approved by the National Development and Reform Commission (NDRC) and small provincial projects approved by Provincial Development and Reform Commissions (PDRC). The loss of market shares over the last few years reflects this fact. Over the last few years, Chinese and European companies have only competed in the 'provincial' markets for turbine parks below 50 MW due to the national procurement specifications in which the national innovation accreditation policy gives preference to domestically owned technology. Nevertheless, in absolute terms the European players have grown from sales to these smaller (below 50 MW) projects. They have succeeded in doing this despite the fact that their upfront prices are typically higher than the domestic manufacturers (BTM 2008).

A strong presence in China has been a key priority for leading European firms as they expect that even though the market is crowded at present, there will be continued demand in the future. There is agreement that China will need to give more emphasis to quality as the sector matures, and that there will be a more important role to play for both foreign manufacturers and suppliers. Today there are firms catering for the entire value chain in China. Table 5.2 lists Danish and German firms operating in China.

Lead firms in the manufacturing chain have expanded heavily in China. By the end of 2009, Vestas had invested more than USD 450 million in China, employing 3,000 workers. The firm has recently established the largest wind turbine manufacturing facility worldwide in China and it has transferred the technology to build the latest electronic controls and generators.

Figure 5.2 Shares in cumulative installed capacity – domestic and foreign brands in China (MW)



Source: BTM (2008); Meyer (2010).

In 2010, it opened its first Chinese R&D centre in Beijing ($50m investment) to undertake work in areas such as high voltage engineering, aerodynamics and material and software development. Up until then, Vestas had been reluctant to open an R&D centre in China due to fear of knowledge leakages (Pedersen 2009). However, the change in strategy seems related to a realisation that R&D investments will be viewed favourably by the Chinese government. This may in turn help Vestas to get access to larger projects in the Chinese market. In this sense, Vestas seem willing to trade technology for market access. Yet there are indications that the most strategic areas of R&D will remain in Aarhus/Denmark.

Vestas also has connections 'back home' in terms of suppliers. Vestas works with several Danish specialised suppliers that are now operating in China. This includes firms such as Svendborg Brakes and C.C. Jensen. By locating in China, these firms could supply to Vestas during the time of local content requirements. Turbines produced in China are almost entirely localised, often with fewer than 10 per cent imported content.

The German wind turbine manufacturer REpower is a good illustration of the argument developed in this paper that the globalisation of the wind power industry does not result in zero-sum competition between Chinese and European lead firms. First it shows that it is increasingly difficult to pinpoint the nationality of lead firms. Lead firms no longer have one passport. They have multiple areas of operation and complex ownership structures. Second, it shows how business model innovation enables the firms to profit in the Chinese market despite fierce competition from domestic Chinese firms (see Box 5.1).

Box 5.1 The globalisation of wind turbine firms: the case of REpower in China

REpower is a typical offspring of the European wind industry. Founded in 2001, the medium-sized company today employs around 2,500 people. At the same time REpower is representative of the globalisation of the wind industry. Since 2007 the majority of the shares of REpower are now owned by the Indian turbine manufacturer Suzlon. Furthermore, REpower has a number of subsidiaries and joint ventures all over the world.

REpower has been active in China since 1997 when it signed a licensing agreement for a 600 kW turbine with the Chinese manufacturer Goldwind. In 2003 REpower signed another licensing agreement with Dongfang to build 1.5 MW turbines. In 2006 REpower set up a Joint Venture (JV) with North Heavy Industry Corporation and Honiton Energy Ltd. to manufacture 2 MW turbines in Baotou, Inner Mongolia, to benefit from the booming Chinese wind market.

In 2009 the company had a market share in China of 1.4 per cent. However, due to the regulatory environment that favours short-term cost competitive solutions, the market share for turbine sales has been shrinking. As a turbine manufacturer REpower, as other international companies, is not able to benefit from the rapid expansion of the Chinese market for wind turbines. As a result the company is evaluating the opportunities to reduce or transfer its main share in this joint venture to the local partner or another powerful player in the Chinese energy business. REpower is shifting its business model in China from being a turbines manufacturer to a system provider, putting a stronger focus on the operation of wind parks and after-sales services.

A comprehensive analysis of REpower’s activities in China reveals that European lead firms can benefit from the expansion of the Chinese wind industry. According to company information REpower had a technical market share of 29 per cent at the end of 2009. As a result of its licensing agreements with Goldwind and Dongfang the company is profiting from royalty fees paid for the erection of each and every wind turbine that is based on its technology. The firm is currently evaluating its licensing strategy in China.

The presence of REpower in China also enables the company to benefit from the Chinese supplier network. As part of the company’s goal to be able to offer a 2 MW turbine at a price below €1 million, REpower is sourcing standardised components in large volumes from Chinese suppliers. As the lead firm of this value chain segment, REpower is setting the standard for production and controls the quality of the components that are afterwards shipped to Europe and North America.

The REpower story in China reveals that the prevailing view of conflict between Chinese and European turbine manufacturers is only part of the whole picture. Through shifting to other niches of the Chinese wind power market REpower can benefit from the expected shift towards higher reliability and quality requirements to increase the energy output of the installed capacity. More importantly, REpower is a good illustration that international lead firms can benefit from China as a sourcing base to drive down turbine costs on a global level.

Source: Authors’ interviews.

The European supply base moved to China to follow European lead firms, but the new growth potential lies in working for Chinese turbine manufacturers. The European suppliers have established subsidiaries providing small specialised components and services in fields such as electric control systems (Mita-Teknik supplies, Dongfang and Windey among others), hydraulics and oil filter systems that reduce wear and tear on components

(CC Jensen) and gears (Niebuhr Gears). These suppliers become more important as the Chinese manufacturers seek to upgrade the quality of their products. In a few cases, there are also alliances for large components such as the European blades supplier LM working with Goldwind, Sinovel, Dongfang and Envision, among others. Unlike the European turbine producers, foreign component suppliers are gaining market shares in a number of areas (authors' interviews).

Table 5.2 Examples of Danish and German firms in China

Value chain function		Sub-functions and firms
Manufacturing Chain	**Turbine design**	*Licences and engineering services*: Aerodyn, Danish Wind Design, DEWind, Norwin, Vensys
	Components	*Blades, Gearboxes, Generators, Bearings, Power Converters, Control System:* Bosch Rexroth, C.C.Jensen, DEIF Wind Power Technology, Fritz Schur Energy, Hansen Transmissions, KK-Electronic, LM Glasfiber, Mita Teknik, Niebuhr Gears, Rothe Erde, Scanpocon, SKF, Winergy
	Turbine Manufacturing	*Assembly*: Vestas, Siemens, Nordex, REpower
Deployment Chain	**Pre-deployment**	*Park design, project management, construction*: COWI, Eltronic, K2 Management, Vestas, Siemens
	Deployment	*Project transportation, lifting and transport equipment, foundations:* BaltShip, Blue Water Shipping, GIS Service & Technology Co, Liftra, MT Højgaard
	Post-deployment	*Operation and maintenance, training courses and consultancy*: COWI, Vestas, Siemens, DUWET, Grontmij-Carlbro, 8.2 Consulting

Source: Interviews and firms' websites.

The segment that has struggled the most to get a foothold in China has been the service provider segment. Some wind power developers such as German InfraVest are operating in the Chinese market, but overall the investment climate is difficult as foreign developers cannot benefit from the same policies as local companies, for instance foreign developers have been faced with a lower feed-in tariff (BTM 2008: 50). However, Li Yan (2009) argues that problems may also be found in China's specific cultural approach of doing business. While there is a seemingly transparent process for tenders, this process is in reality fraught with 'hidden rules'. The tender with the highest score does not necessarily win the bid. Rather, the final decision is made by government officials. Managers of the state-owned firms and government officials sometimes have personal connections, or 'Guanxi' network relationships. Absence of such relationships is a much larger barrier to the private sector overall – and foreign firms in particular – than specific laws and regulations. Foreign developers have been involved in setting up 5 per cent of installed capacity, and most of these projects have been joint projects, meaning that the foreign players typically own less than half of the project (Yan 2009).

With regard to other aspects of the value chain, many consultancy houses from Europe are engaged in advisory works under the Danish and German state-sponsored programmes (originally aimed at capacity building in the Chinese industry). Examples are the Danish-Chinese Wind Energy Development Programme (2006–9) and the Sino-Danish Renewable Energy Development Programme (2009–13). The latter programme aims at establishing a China national renewable energy centre – co-funded by the Chinese and Danish governments – contributing to sustainable development in China through capacity building and technological innovation. Germany established a Wind Power Research Training Centre (2005–10) which, among other things, developed solutions and procedure for functionality and quality testing. Danish and German providers of technical and other knowledge intensive services – individuals as well as firms – have an established history of working in China in connection with such programmes and projects.[11]

However, on a commercial basis, the European consultancy service firms have been struggling to gain a foothold. Firms such as COWI and Grontmij/Carl Bro are operating in China but at a relatively modest level. Despite European competencies in offshore implementation, none of them have been involved in the large Chinese offshore projects (authors' interviews). Nevertheless, the internationalisation of European firms in the sector means that every turbine installed in China, whether a Chinese or European turbine firm assembles and installs it, typically incorporates and draws on a range of European products or services.

5.4 Chinese lead firms in global markets

Competitive relations between the EU and China will depend significantly on the ability of Chinese firms to penetrate export markets. It is to be expected that the larger Chinese wind turbine manufacturers, just like their European competitors (or the Indian company Suzlon), will increasingly have to sell their turbines abroad. Before 2008, there was no Chinese turbine installed in any country outside China, but in recent years, some of the leading firms have begun to gain export experience. In the coming years these exports will challenge European manufacturers. Turbine prices have recently been falling below €1 million a megawatt for the first time since 2005 (BNEF 2010).[12] Competition from Chinese firms with low production costs is likely to put pressure on European firms in the near future (Prideaux 2011).

As mentioned, wind power is globalising increasingly through FDI rather than through trade (Kirkegaard *et al.* 2009). Most elements of the deployment chain are 'non-traded' (internationally) because of the physical need to co-locate production and consumption. International tradability in the manufacturing chain is impeded by the high transportation costs of turbines and many of the key components. It is very likely that Chinese firms will increasingly set up manufacturing plants outside China for assembly and certain components, while shipping other elements from their Chinese factories. In addition, they are likely to form new relationships with global suppliers in these markets.

Chinese exports in 2010 are shown in Table 5.3. Goldwind started exporting to Cuba in 2008; and later in 2009, they sold three turbines in the US market. The firm has recently established a wholly-owned subsidiary in Chicago, seeking to address a US market dominated by GE. It was the first Chinese manufacturer to sell turbines outside of the Chinese market (Zeller and Bradsher 2010). This was preceded by the firm's buying up of a production base in Germany (Vensys) and a subsidiary in Australia.

Sinovel have declared the goal of becoming the largest turbine maker in the world by 2015 with half of sales being for foreign markets. In 2009, Sinovel exported ten turbines to India. Whilst initial numbers are small, it marks a change in the ambition and outlook of the largest Chinese manufacturer. Sinovel is currently the third largest in the world (based on sales), just

11 While most of these programmes have grown out of the donor world in Europe, they are now changing in nature. There is now a growing business component to these programmes, reflecting the increasing maturity of the Chinese sector and its emerging ability to compete globally. This type of cooperation is becoming an increasingly sensitive issue because capacity building and cooperation has implications for competition between the European and Chinese players. This point was reinforced by the comment from private sector interviewees who heavily criticised the German Eldorado programme and the Danish B2B Renewable energy programme for helping the competitors of European firms.

12 In ideal conditions, the cost of generating wind power has fallen below $69 a megawatt-hour, which compares with $67 for coal-fired power plants (BNEF 2011).

behind Vestas and GE. The US market will be particularly important, but the European market is also likely to be targeted. In 2011, Sinovel has signed a strategic alliance agreement with Greek utility firm Public Power Corporation (PPC) to develop projects over the coming years, both onshore and offshore, from the base of an assembly plant and a generator plant to be built in Greece, the first plants outside China. Importantly, Sinovel will invest around €450 million, not only in building the parks but also in providing project finance for jointly developed projects.

Project finance may become an important element of China's 'mode of entry' in foreign markets. While the rest of the world is 'strapped for cash', Chinese firms are cash rich. Sinovel, for example, has a USD 6.5 billion line of credit from government-owned Chinese banks (Zeller and Bradsher 2010). Other firms also have strong relations with Chinese financial institutions and have secured significant credit lines for expanding sales outside China. China Exim Bank has injected capital into Ming Yang and Goldwind to support expansion into the US and the EU.

Table 5.3 WTG exports completed and contracts announced, selected Chinese firms

Company	Year	Destination	Units	Unit Type	Export volume
A-Power	2010	US	1	2.05 MW	2.05
A-Power	2011*	US	240	2.05 MW	600
Dongfang Electric	2012*	India	166	7.5 MW	N/A
Goldwind	2008	Cuba	6	750 kW	4.5
Goldwind	2009	US	3	1.5 MW	4.5
Goldwind	2010	Cuba	6	750 kW	4.5
Goldwind	2012*	US	N/A	1.5 MW	120
Ming Yang	2010	US	1	1.5 MW	1.5
Shanghai Electric	2009	UK	3	1.25 MW	3.75
Shanghai Electric	2009	Thailand	2	1.25 MW	2.5
Sinovel	2009	India	10	1.5 MW	15
Sinovel	2012*	Greece	N/A	N/A	300

Sources: CCB International (2011), drawing on data from CWEA; press reports.
* Contracts announced.

This opens up the possibility of an export model that has not been utilised by European firms – the twinning of wind farm project finance and turbine exports. Chinese manufacturing firms are thus indirectly providing credit to projects that would perhaps not be financed by financial institutions in export markets due to the limited record of accomplishment of Chinese turbines. The financing element may thus help Chinese firms get a foot in the door of the US and European markets.

To this should be added the low cost of Chinese turbines. This can be achieved by shipping key components from the Chinese supply network. A value breakdown of a Sinovel 3 MW turbine installed in the US, showed that more than half (blades 23 per cent, gearboxes 13 per cent and other components 10 per cent)[13] was sourced from firms originating from China (BNEF 2010). On the other hand the higher quality assistance requirements overseas means that Chinese turbine makers will forge relationships with global suppliers. Goldwind recently

[13] Towers (around 25 per cent) are usually produced locally. In the longer run, blades are also likely to be produced locally.

signed a long-term supply deal with a number of large European and international component suppliers – including LM (blades), The Switch (power converters) and Timken (bearings) – in order to cultivate a global supply chain. This is an element in the drive to explore the overseas market. Utilising a combination of the Chinese and international supply base – creating a winning cost-quality combination – combined with finance options means that China is developing competitive advantages that are attractive outside China. This will therefore have an important impact on global competition in the wind market.

In Europe, Chinese exports have been modest so far, but the sector is changing rapidly and Chinese firms' foray into Europe is well under way (Prideaux 2011). Interestingly, most of these investments are R&D focused. As mentioned, Goldwind bought a 70 per cent share of the German company Vensys after years of technology cooperation. Min Yang has an agreement with the Danish Risø National Laboratory for Sustainable Energy for their 2.5 MW and 3.0 MW two-blade technology for the offshore market. To boost this linkage, Ming Yang has established a small office – the Ming Yang Wind Power European R&D Centre – in Denmark. Envision Energy has established an R&D facility in the greater Aarhus area with the objective of developing larger turbines for the global market.[14] These are strategic knowledge and asset seeking investments, tapping into the capabilities of the European clusters in wind power (Torp *et al.* 2010).

There are two good reasons why openness will work for China. First, openness to competition is likely to improve management and capabilities at the firm level. The drive to go abroad is likely to make Chinese firms stronger as it creates exposure to international standards – especially certification standards – and management practice.[15] Second, tit for tat protectionism does not work for China at the national sector level. Observers note that Chinese firms may face protectionist hurdles in Western countries unless they liberalise their own market in China and reduce non-tariff barriers to market entry. These two reasons provide strong incentives for internal policy adjustments. The next section sets out a third reason: the continuing need for cross-border technology collaboration between China and the OECD countries.

5.5 Technological development

An important question for determining the prospects for competition and cooperation is how much the Chinese turbine manufacturers have advanced in catching up technologically with firms in the EU. International technology transfer has been an important source of technological capacity in wind turbine development. In the past, Chinese manufacturers have used licensing arrangements to acquire modern, though sometimes not state of the art, wind turbine technologies from European design houses or smaller turbine firms. This has been an effective means of gaining a foothold in the industry and building capacity.

As seen in Table 5.4, many of the European and American design houses have licensed out models to more than one firm. This provides part of the explanation as to why the Chinese industry is organised in more modular fashion compared to the European industry. In Europe, all lead firms have their own designs. As Chinese turbine firms share designs, there is a greater scope for achieving economies of scale in the component supply base. Interestingly, this trend may continue as American Windtec (AMSC) is working with all the big Chinese manufacturers to build their next generation turbines (see Table 5.5).

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14 Recently, it has received permission from local authorities to erect a prototype of its latest GC-1, a two-blade 3.6 MW turbine. Interestingly, the test period for the prototype turbine will be a minimum of three years, thus aligning with the longer European test periods.

15 The problem is to crack open the export markets. Some observers note that given the generally poor managerial capacities of Chinese companies conducting investment projects abroad, Chinese wind turbine manufacturers will face tough challenges to expand out of their markets (e.g. Hanemann and Rosen 2009). However, one question arising out of this observation is whether the Chinese firms are currently buying in managerial capacity for expansion in foreign markets such as has been witnessed in the electronics sector.

Table 5.4 Links between design firms and Chinese turbine firms

Design House	Chinese Firms
Aerodyn (DE)	Haizhuang, Huayi, Ming Yang, Sewind, United Power
DeWind (DE)	Beizhong, Sewind
Fuhrlander (DE)	Sinovel, A-Power
Norwin (DK)	A-Power
REpower (DE/IN)	Dongfang Electric, Goldwind
Vensys*(DE)	Goldwind
Windtec (US)	Sinovel, Jingcheng, Sinovel, Zhuzhou, Dongfang, Shenyang, ZELRI

Sources: CCB International 2011; company data; press reports.
*Goldwind is now owner of Vensys.

The option of tapping into established design and engineering capabilities in overseas firms has been key to the Chinese success story (Lewis 2011). Companies like Goldwind have been able to absorb these technologies and thereupon established the basis to innovate on the transferred technology. Something akin to an organisationally decomposed innovation system exists in the wind power industry. Even a leading firm such as Vestas follows elements of an innovation decomposition strategy, collaborating with external research institutions and universities, because it is too costly and complex for the firm to pursue leadership in all areas on its own (Pedersen 2009). Most leading European firms carry out the turbine design function in-house. Chinese firms have developed some in-house capabilities but rely more on licensing of turbine design and components. They also engage in co-design by joint engineering teams from different firms in the value chain.

The leading companies are today able to sell wind turbines up to the size of 3 MW and several firms are working on the development of 5 MW turbines (Table 5.5). Relationships with overseas technology partners have developed from licensing (Table 5.4) to co-design partnerships and own innovation (Table 5.5).

Overall, the ‘technology transfer mechanisms’ have shifted from traditional mechanism (e.g. FDI, trade and licensing) to non-traditional mechanisms (joint design and R&D collaboration, overseas R&D units, etc.) (Lema *et al.* 2011). Non-traditional mechanisms tie in to the organisational decomposition of the innovation process (ODIP). Box 5.2 discusses the role of ODIP in the Chinese wind power case. Chinese firms have benefited from this ODIP trend, in particular from licensing arrangements that they have used as a foundation for their own learning and innovation.

Many licensing arrangements have gradually transformed into co-design relationships. In addition, Chinese manufacturers have bought up complete engineering bureaux – such as those in Vensys and Darwind – in order to build up indigenous technological capacities (authors’ interviews). However, Chinese champions have built up significant in-house R&D capabilities too. Sinovel, for instance, has more than 600 people working in R&D (authors’ interviews). Such in-house capability creates the absorptive capacity required to harness external technology linkages. Despite the decomposition trend, the bulk of innovation in the wind sector still takes place within R&D departments of large established companies. R&D efforts typically address increase in turbine size, cost reduction and wind power products tailored to the future offshore market. To this should be added that such indigenous innovation efforts are buttressed firmly by state support. For example, the Chinese government has stipulated that turbine manufacturers should aim for turbines bigger than those of overseas competitors, not least for the offshore market. To support this, R&D expenditure on bigger-sized turbines is earmarked for VAT refunds.

Table 5.5 New turbine development

Turbine	Company	Design	Prototype	Serial production
3.0 MW	Sinovel	Sinovel and AMSC	2009	2010
3.0 MW	Goldwind	Goldwind	2009	2010
3.0 MW	Ming Yang	Ming Yang and Aerodyn	2010	-
3.6 MW	Shanghai Electric	Shanghai Electric	2010	-
5.0 MW	Sinovel	Sinovel and AMSC	2010	-
5.0 MW	Dongfang	Dongfang and AMSC	2012	2013
5.0 MW	XEMC	XEMC Darwind B.V.*	2010	2011
6.0 MW	Sinovel	Sinovel	2011	-

Source: Drawing on Azure International (2010); press reports. *XEMC have now acquired Darwind B.V.

The question of whether China is becoming a technology leader in this industry is controversial. Some argue that China's rapid technology catch-up has been based on licensing foreign technology and question whether China can innovate on its own. Our research has indicated that indigenous technological capability is increasing rapidly in China, but the real innovative power lies in business model innovation. Inter-firm relationships are central to the Chinese model: lead firm-supplier relations buttress a flexible low-cost industry structure (as discussed in Section 5.1) and relationships to technology suppliers complement in-house expertise (as discussed in this section, above). Chinese firms do not seek to 'go it alone' in technology development. The Chinese lead firms seek to develop turbine technology in cooperation with foreign partners. This may prove just as effective as a technology strategy that prioritises independent in-house development. Chinese firms are now working with overseas partners on turbine prototypes that are just as advanced as those being developed by firms in the West (authors' interviews).[16]

China's problems seem to be less in the manufacturing chain than in the deployment chain. There is agreement that capacities and capabilities in the manufacturing chain have outpaced those in the services chain, as is evident from the relatively low rate of utilisation in Chinese wind power projects.

[16] This was stated by independent industry consultants with in-depth knowledge about technology in Chinese industry. In the meanwhile, Vestas have announced that they have been working 'below the radar' on a 7 MW turbine.

Box 5.2 The organisational decomposition of innovation in the global wind turbine industry

The organisation of innovation is changing rapidly across a range of global industries, including sectors such as the automobile industry and electronics hardware and software. The innovation process tended to be centralised at or near the headquarters of lead firms but is now much more decentralised within the company. Equally, if not more significant, innovation activities that used to be carried out in-house by innovating firms themselves are now carried out by independent suppliers of knowledge intensive business services, or are transferred to key suppliers. This process has been referred to as the 'organisational decomposition of the innovation process' (ODIP). Recent research has sought to examine ODIP and assess whether it contributes to changing the division of capabilities and innovative labour between OECD countries and emerging markets such as Brazil, China and India.

The research reported in this paper shows that Chinese turbine manufacturers have adopted ODIP technology strategies. The main component of this strategy was external to the firm: turbine design licensing and overseas collaborative R&D in the form of joint turbine design. However, there was also an in-house component, particularly through creating global R&D subsidiaries through overseas acquisitions of firms but also with establishment of research and design subsidiaries in established knowledge clusters. This strategy seems to have been highly effective, not least in terms of the speed of capability building. These firms have made the transition from production to innovation capability in less than a decade. Ten years ago, all domestic manufacturing was based entirely on technology developed in OECD countries. Today, these firms are selling turbines based on their own technologies.

These strategies were made possible by organisational changes occurring across the industry in a variety of countries. The strategies depended on business model changes among firms in OECD countries. The Western firms sought to commercialise their technologies in the external market. They were either dedicated design houses without manufacturing capacity or smaller WTG firms that did not compete head-to-head with domestic firms in China. They were located in established knowledge clusters and often employed engineers and other R&D staff with prior careers in the major lead firms.

These trends are similar to development in other green technology industries such as solar photovoltaic panels and electric vehicles. However, they differ in key respects from trajectories in the auto and software industries. In the latter industries, the main effect of ODIP was through lead firms' FDI offshoring and outsourcing of R&D and design and engineering (D&E) to emerging markets. Such lead firms' relocation of innovation is now picking up in wind power, but it was not a main cause of innovation capability in domestic firms. Rather, it was Chinese lead firms' own ODIP strategies that contributed mostly to the changing global distribution of technological innovation capacity in the manufacturing segment of the wind power industry.

Sources: Drawing on interviews, secondary literature on the wind power industry (Lema and Lema 2011; Lewis 2011) and literature on ODIP (Schmitz and Strambach 2009; Lema *et al.* 2011).

6 Competition and cooperation between Europe and China

Most accounts portray green technology trade and investment relations between China and the EU in terms of winners and losers. However, the analysis of the wind power industry provided in this paper suggests that it is a fallacy to describe the relationship in such simplistic terms. In this paper, we have sought to go beyond the headlines and we find that there is little zero-sum competition between China and Europe. Our analysis shows that there are multiple connections between Chinese and European value chain actors. While Chinese and EU firms compete, they also collaborate. The prospects for collaboration are increasing with the globalisation of the industry.

To show this, the previous sections have set out the European and Chinese wind power chains respectively. The sections sought to decompose the ‘double chain’ and revealed how the European and Chinese organisational models differ and how there are strengths and weaknesses in different elements of the chains.

There are also different motives and priorities regarding investment in capabilities. Europe hosts a range of mature firms that have made the shift from locally and regionally oriented firms to global firms (BTM 2010: 32). It is accepted that manufacturing will be undertaken globally, but firms and policymakers seek to retain innovation functions in established European knowledge hubs. China, on the other hand, is driven by the prospects of technological catching up (and leapfrogging) in an industry of the future. While there are already strong Chinese firms, particularly in the manufacturing chain, these are only now entering the process of going global. This is set to disrupt international competition and change the nature of collaboration.

In this last section, we bring together the elements of the analysis to address the issue of competition and collaboration between Europe and China now and in the future. We first seek to pull together the insights regarding how China’s emergence in the global wind power industry affects patterns of competition. We then show that there is already much cooperation going on between firms in China and the EU and that there are opportunities to develop several types of collaborative relationship further. Finally, in the concluding section of the paper, we contrast three scenarios for the future and use the analysis in this paper to assess their prospects. We emphasise that outcomes depend on the policy stance of governments and we therefore end with policy recommendations for both China and the EU.

6.1 Competition

The Chinese wind power industry has developed through three broad phases. In the first phase, wind power equipment was imported from abroad. In the second stage Chinese firms started to manufacture turbines for the domestic market themselves, first based on design from abroad, but increasingly based on co-design or own design turbines. The third stage – which Chinese firms have entered only very recently, and still in an uneven way – is the globalisation stage in which they begin to address the global market. During the course of this extremely rapid transition, the industry has built a distinct and durable, yet flexible, value chain structure and a robust but flexible model of industrial organisation. While exporting remains a ‘next step’, there is widespread agreement that these firms will transform the global market in coming years. So, is there currently a dilemma of European companies *vis-à-vis* Chinese companies? The answer to this question is that it depends on the market. Different markets – Chinese, European and other markets in developed and developing countries - have different characteristics. The key contrast is between fast growing and segmented markets (high and low quality) in China and some other emerging economies, and relatively static and homogeneous high quality segment markets in the EU and other OECD countries.

So far, the competitive dilemma exists mainly within China. The Chinese market is set for continued growth at breakneck speed, but the market has also seen a big influx of new players in recent years. The Chinese market is likely to see some consolidation through mergers and acquisitions in the coming years. This is also likely to happen externally, including a further shift of European firms to Chinese ownership – which is likely to strengthen the competitive position of Chinese firms. Yet, as the Chinese wind energy sector gives more emphasis to quality as the sector matures, there is likely to be decreasing tension, as there will be a more important role to play for foreign firms in the Chinese markets. It is now becoming apparent that foreign firms in China are increasingly localised, with little content shipped in from overseas and that European turbine firms source from Chinese as well as international suppliers.

In the European market, there has so far been less of a trade-off. The European market is currently dominated almost exclusively by European firms. However, this has begun to change. As discussed, Chinese firms are expanding and although the European market is not on the top of their agenda, Chinese firms are likely to bid further for European projects in the future. In Europe, there is already significant competition between firms from different member states, but this competition will intensify as Chinese firms manage to throw in different price equations, consortia models and financing options. It remains an open question whether EU firms will seek to lower costs via innovation, or compete on quality not price.

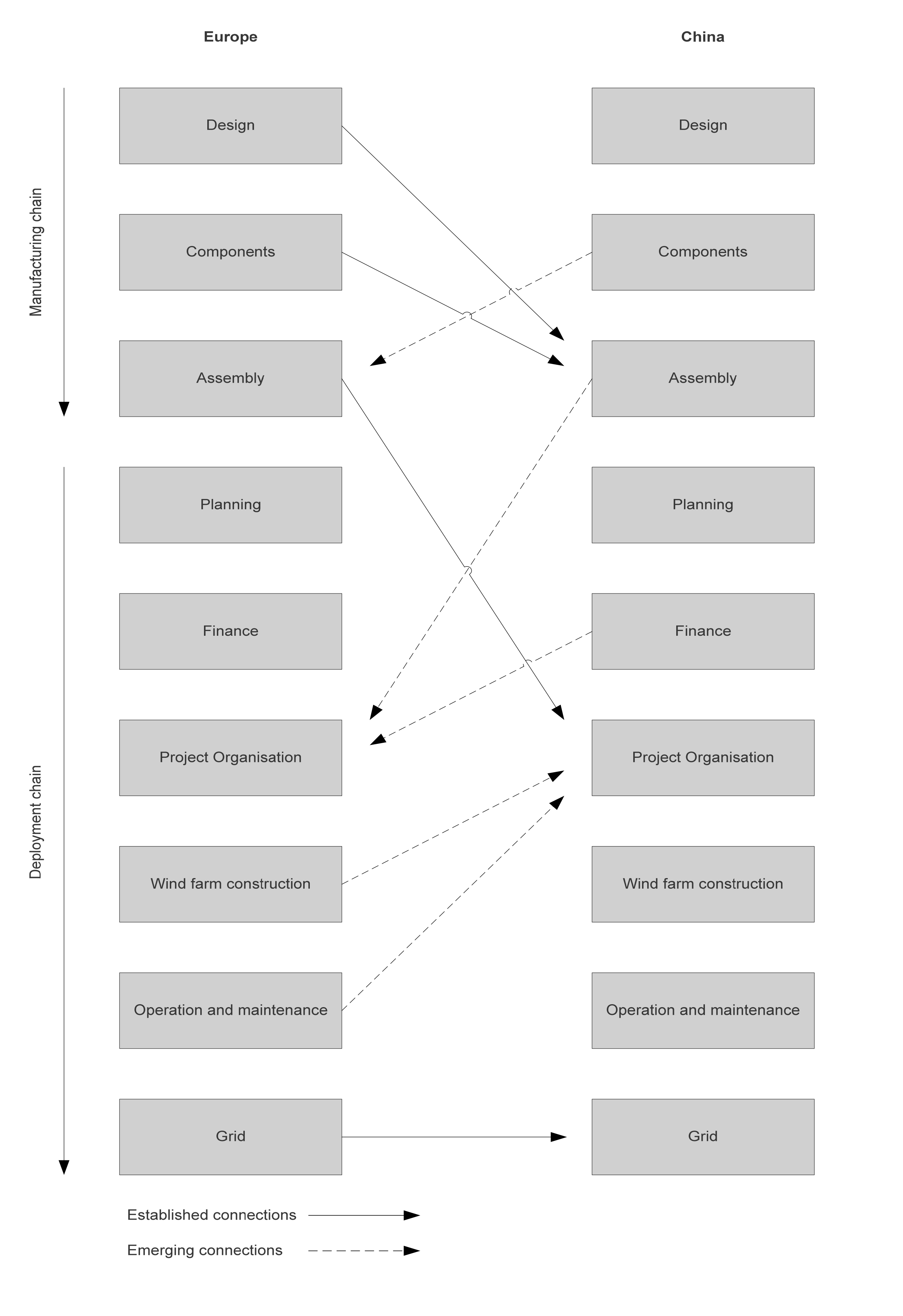
Chinese and European companies will also compete head-to-head in other markets such as in the USA and in developing countries. It remains to be seen whether and how they will develop into a geographical and or technological division of labour. One hypothesis is that by growing the global wind market and driving down prices, China will help wind power become more affordable and look credible overall. This will help create new markets in rapidly growing economies such as Brazil, South Africa, India and Indonesia. This might create significant market opportunities for both sets of players.

6.2 Cooperation

Crucially there is scope in all three market domains – China, Europe and third markets – to combine capabilities from across the continental divide. To grasp this, it is necessary to go beyond the usual focus on turbine manufacturers alone to: (i) decompose the value chains; and (ii) pay attention to changes over time. A static focus on these lead firms alone would lead to the conclusion that relationships are mainly or even merely competitive. However, when we start to unpack GVCs it emerges that there are a number of key areas of collaboration. Figure 6.1 unpacks the chain and seeks to map some of the key current and (expected) prospective connections that are likely to form with the further global integration of the industry. This figure only captures key connections and cannot capture the entire complexity. Nor is it feasible to describe all of the identified links, but it is worthwhile to mention some of the most important ones.

The first type of cooperative relationship is between turbine manufacturers and providers of knowledge intensive business services (KIBS) such as various types of technology consulting and designs and licences. The key relationships are between European specialised technology providers and design houses (e.g. German Vensys and Fuhrländer or Danish Norwin) and big Chinese turbine manufacturers. As mentioned, these types of technology focused collaborative relationships for turbine design are increasing in importance as the emphasis in China shifts from conventional technology transfer to

Figure 6.1 Links across chain functions



collaboration (Lema and Lema 2011). Although the independent design capabilities are increasing fast (see section 5.5), these are likely to continue to be complemented with external partnerships in the future.

The second type is between turbine manufacturers and component suppliers. Reflecting the globalisation of the supply base, relationships are now emerging between European component suppliers and Chinese turbine firms. While European turbine manufacturers see tough challenges in the Chinese market, many component suppliers are hoping to deepen these relationships and benefit from ambitious Chinese wind power growth plans and increasing attention to turbine reliability. As mentioned, relationships between Chinese firms and global component suppliers will strengthen as the Chinese firms go abroad. Conversely, European turbine firms have long worked with Chinese suppliers for sales in the Chinese markets and it appears likely that these relationships will strengthen as the use of certain components in international assembly can enhance price competitiveness in global markets.

The third type of relationship is foreign direct investment in knowledge intensive areas. Policymakers in Europe stated that they hope to attract investment from the Chinese turbine industry so that Chinese firms can benefit from accumulated knowledge built up in Denmark and Germany. As subsidiaries are incorporated in Europe, these Chinese firms would have opportunities to participate in R&D programmes and other initiatives. However, Chinese investments have been relatively modest so far. European firms have begun to locate substantial R&D investments, such as Vestas' recent expansion of its R&D network, to China to undertake research and expand cooperative relationships with organisations such as State Grid.

Fourth, there is currently a large but under-utilised scope for cooperation between manufacturers and project organisers and various types of KIBS in the wind power deployment service chain, including site design, specialised transport and construction of equipment and operations and maintenance. For instance, there is an obvious fit between Chinese offshore ambitions and the European ecosystems of solution providers with accumulated expertise in offshore implementation. Partnerships can be formed between Chinese turbine firms and European offshore installation and O&M firms.

Fifth, there are opportunities to develop new financial and business model arrangements, for instance involving utility firms, such as the model devised by Greek PPC and Sinovel. This highlights the fact that new types of arrangements that were almost unthinkable a few years ago are possible. There are obvious possibilities to align European utility companies, associated consortia and Chinese firms who can bring along cost-competitive equipment and project finance for the European market. Such consortia carry the potential for mutual gain by combining complementary capabilities and sharing the gains of collaboration.

There are also opportunities to deepen relationships supported by government programmes. China and Europe have an established history of cooperation in the wind power field, with Denmark and Germany in the lead on the European side, whereas other countries (including the USA) do not have such programmes. Most future government-to-government collaboration programmes and projects will therefore be concentrated in 'non-tradable' technological areas such as grid code definition and standard setting.

6.3 Three scenarios for the future

The objective driving this research was to assess the prospects for competition and cooperation in the wind power sector. Two major developments have put this issue on the top of the agenda. The first is the shift of innovation power from Europe to China. This shift remains uneven, but it is already clear that China is accumulating innovation capabilities at considerable speed. The second is the ‘green turn’ in the global economy associated with massive investments in green technology sectors such as wind power. European industrialists and politicians claim that low carbon sectors offer opportunities for Europe to (re-)establish its eminence in production and innovation. Meanwhile China is building up its own production and innovation capability in wind power equipment. These changing conditions in the business and political environment prompted us to examine the nature and implications of growth in this sector.

The complex picture of current relationship patterns makes it difficult to forecast long-term outcomes. However, it is possible to discern three scenarios: (i) conflict between nations; (ii) global cutthroat competition between enterprises; and (iii) global cooperative competition.

The tensions that could lead to a *conflict scenario* are portrayed in many press reports on green technology trade and investment issues (Hamlin 2009; *Nature* 2009; *China Daily* 2011; *Shanghai Financial News* 2011). Many such reports are written from the point of view that China and Europe play a zero-sum game in the wind power industry. They emphasise the elements of the relationships that are associated with trade war and protectionism. In a conflict scenario, China would further increase barriers to foreign investments and discriminate against foreign enterprises in national markets. The EU would reciprocate – with the USA – by challenging China in the World Trade Organization over public procurement policies, seeking to restrict Chinese investments and seeking to ‘shield off’ established knowledge clusters from Chinese firms. While it is unclear whether such strategies could ultimately prove effective, such a scenario would hamper globalisation in the industry, forcing firms to focus mainly on domestic markets. Such a scenario would be detrimental to green technology cost reductions and innovation.

Today, reality on the ground is moving in the opposite direction. As the key actors in the wind power industry increasingly shift from home-focused to global strategies, observers have brought the all-out global *competition scenario* to the table. It is portrayed (implicitly) in studies and reports written with the objective of harnessing the potential of globally open trade and investment flows in wind power (Kirkegaard *et al.* 2009).The global competition scenario would depend on further reductions of trade and investment barriers such as tariffs, local content regulations and nationally specific certification standards. From a climate change mitigation perspective, there are important advantages of global competition as it increases economies of scale and drives down costs. This is needed because hitting the targets for greenhouse gas emission requires cost reductions in key technologies.

However, in their pure forms, both the conflict and the global all-out competition scenarios seem unlikely. Both China and the EU recognise that the risks of conflict are counterbalanced by forces that lead to mutual gain. China realises that further technology transfer and collaborative arrangements are required for its firms to compete internationally. The EU realises that shielding off established knowledge clusters is impossible. Access to markets, including markets for technology, raw materials and labour, is essential for the success of both parties. This means that positive tit for tat policies are more likely than negative ones. In terms of competition, it will increase as markets expand and new entrants arrive on the scene. But at the same time, there is much more going on than one-dimensional competition. To unearth this, it is necessary to unpack the value chain, consider the range of value chain stakeholders that make up the industry, recognise that Chinese and European firms are in fact international firms adopting a global business logic, and adopt a dynamic perspective that pays attention to changes over time. This is what we have tried to do in this paper, and this has helped us to identify the scenario of global *cooperative competition* and reflect on its prospects. As discussed above, the possibilities for cooperation are increasing with globalisation in the wind power industry but this outcome will not occur automatically. It requires government intervention.

Apart from continued industry support in the form of feed-in tariffs and the like, policies should be designed to create framework conditions that encourage healthy competition in the sector, through support for establishing strong global standards across the manufacturing and services chains and through open investment regimes. Regarding the latter, China has already taken important steps with the removal of local content requirements on wind turbines. Further steps can be taken, for instance, by adjusting the criteria guiding internal investment decision-making such as in national concession projects. This is likely to happen when China itself seeks to address overseas markets in a big way.

On the European side, policymakers should ensure foreign investment from China has long run support – also in the future when Chinese firms emerge as serious competitors to domestic firms in the European markets. We recognise that 'some people would argue that the EU should be looking to protectionist measures to help its industries compete in an increasingly aggressive international market' (Neslen 2011). However, this is not in Europe's own interest. It is in Europe's interest to forge long-term relationships and institutional support systems. As globally leading regions for wind power support and development, China and the EU have a major opportunity to demonstrate models for global low-carbon economy regimes through engagement with bilateral agreements on trade and investment.

However, creating such a framework should be viewed only as a minimum requirement. The next step is to take a proactive approach to collaboration. Discussions so far include creating further public joint R&D projects in grid technology and European turbine manufacturers 'investing in advanced R&D partnerships with Chinese counterparts' (Conrad and Meissner 2011). More promising are the new collaborative business models in which Chinese and European partners occupy *different* positions in the value chain. A range of complementary strengths and capabilities can be identified which can form the basis of new types of partnerships. Such arrangements will need to use the Chinese and European markets as test-beds, but may also prove competitive in global markets. For these to emerge and work, government actors will need to play a convening role in bringing together stakeholders in new partnership models. China and the EU can drive the global green growth economy and set international benchmarks in the drive to reduce the costs of wind-generated power to levels competitive with traditional energy sources. Turning this opportunity into reality cannot just rely on the market. It needs public intervention which identifies and fosters the common interests across the Europe–China and across the public–private divide.

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