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INVOLVING STAKEHOLDERS TO PROMOTE COMMERCIALIZATION OF A TECHNOLOGICAL INNOVATION

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ABSTRACT

This paper reviews wind energy industry recent developments in order to set the context for an investigation into the commercialization challenge met by a large European company when launching a new, innovative wind power tower structure into the markets. The empirical work conducted was explorative, comprised of qualitative expert interviews. Although the empirical research was only at the explorative stage, it already pointed toward some interesting observations that resonated with received continued innovation theory. Particularly important was the observation that for a company such as the case company here, which only manufactures one wind turbine part, it would be nearly mandatory to innovate in terms of its business model, aiming to become part of a collaborative, closely networked value chain that could present a united front to the customer. However, to alleviate the uncertainties of potential partners, a demonstrative trial would be precious.

Keywords: Stakeholder, innovation, commercialization

1. THEORETICAL BACKGROUND AND RELEVANCE

1.1 TRADITIONAL GEOPOLITICS OF ENERGY

Energy is crucial for the functioning of industrialized economies: a country's ability to access energy supplies decisively determines the state of its economy, national security, and the quality and sustainability of its environment (Shaffer, 2011). This has held since the time of the Industrial Revolution, when an entirely new set of energy dynamics was introduced to the world. Pre-industrial societies had access only to very limited energy supplies from human or animal muscle and depended on the annual cycle of plant photosynthesis for both heat and mechanical energy. The quantity of energy available in pre-industrial societies each year was therefore limited, and economic growth was necessarily constrained. The Industrial Revolution dramatically changed this, as coal usage vastly increased individual productivity and consequently transformed the productive power of societies (Wrigley, 2010, 2013).

The demand for energy, and specifically electricity, has increased dramatically during the past century (Gasch & Twele, 2012). So far, most of the energy needs of countries around the world have been met through the use of fossil fuels, mainly crude oil (petroleum), coal, and natural gas. Among the fossil energy sources, oil has been primary because of its high energy density and easy transportability. In fact, oil is by far the largest single commodity in international trade (Gasch & Twele, 2012). Both of these tendencies are demonstrated in 2012 energy statistics in *Figure 1*.

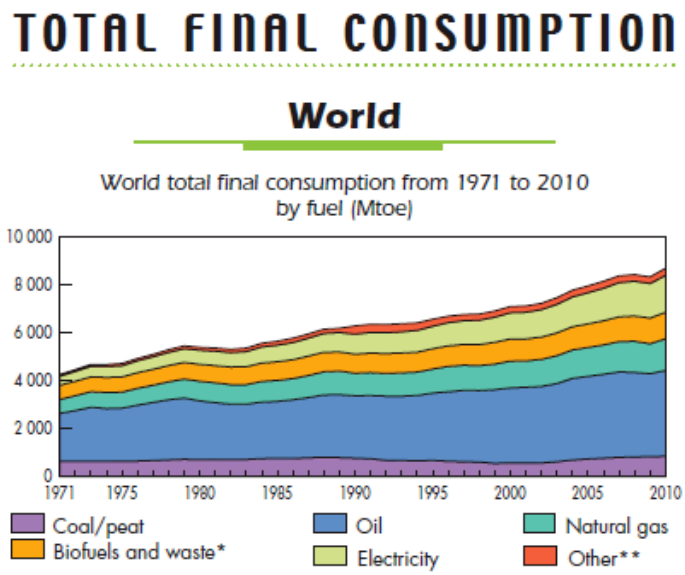

Figure 1: Total final energy consumption by fuel (Source: International Energy Agency, 2013)

However, since oil fields are located only at certain places on earth, merely a select group of countries are oil-independent, while others depend on the oil production capacities of this handful of countries (Goldthau & Witte, 2010). This dilemma is demonstrated in *Figure 2*, which illustrates the concentration of oil reserves in the Middle East while, as *Figure 3* shows, the greatest oil consumption takes place outside the Middle East.

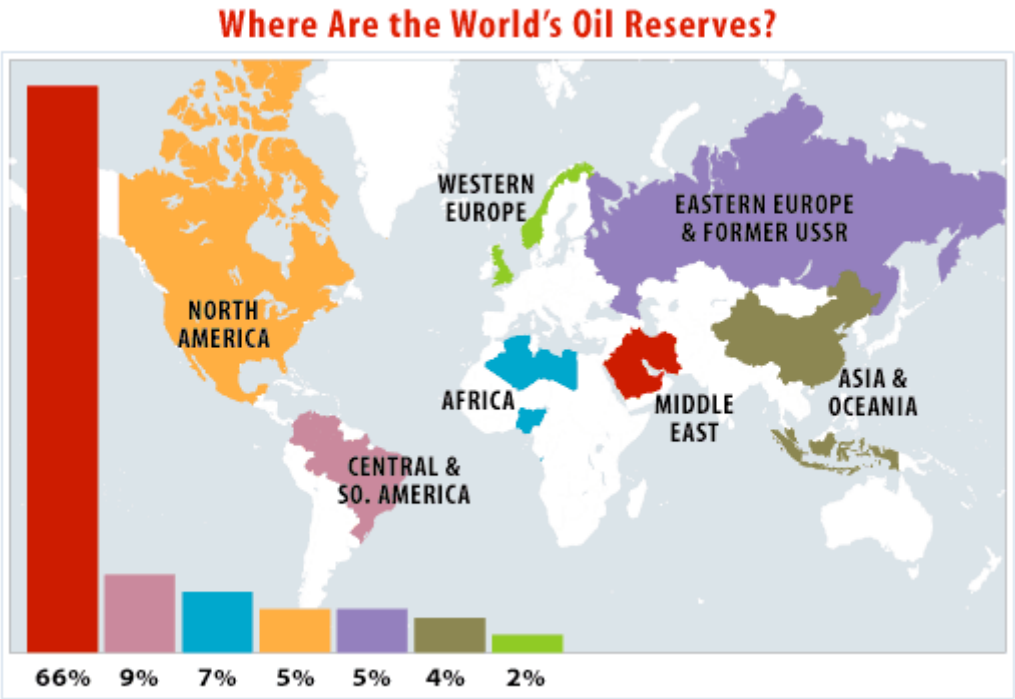

Figure 3: The location of world oil reserves (source: Montero, 2002)

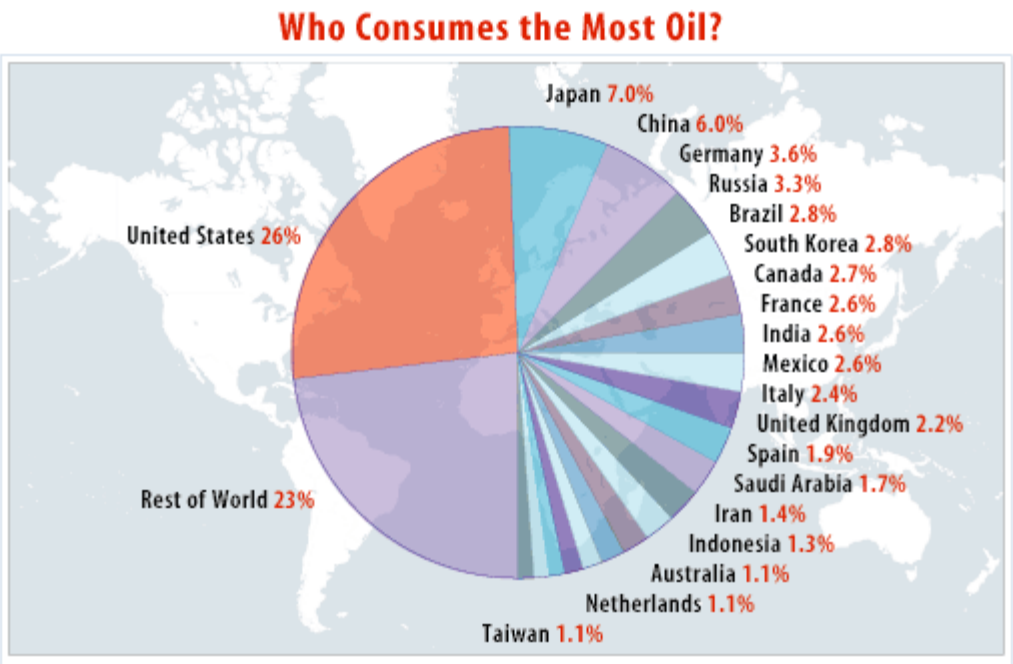

Figure 4: The global consumption of oil (source: Montero, 2002)

As the figures above illustrate, there is a considerable misbalance between the countries supplying oil and those demanding it. This problematic nature of dependence of much of the world on a few oil-producing countries first manifested itself in the 1970s, when the OPEC embargo created an energy crisis with dire consequences in oil-dependent economies. Nonetheless, a period of relative calm followed the 1970s turbulence as global energy markets were liberalized and a fragile peace created in the global energy markets for about two decades (Shaffer, 2011).

Yet, the fragile peace in global energy markets is, however, again showing signs of trouble because of renewed oil price volatility, concern over global climate change, tensions in the international political situation, and the economic rise of China (Andrews-Speed & Dannreuther, 2011; Hughes & Lipscy, 2013; Parry & Darmstadter, 2003). China's rapid industrialization has made the imbalance between oil producing countries and oil consuming countries continuously more skewed, as China has been globally growing its energy demands to fuel the meteoric growth of its economy (Andrews-Speed & Dannreuther, 2011; Hughes & Lipscy, 2013) while possessing only meagre domestic oil and other fossil fuel reserves (Ni, 2010). To keep fuelling its economic miracle, China has embarked on an ambitious global hunt for energy (Konan & Zhang, 2008; Zweig & Jianjai, 2005). The world's other main power blocs, particularly the United States, have reacted to this intensifying competition for global energy sources by fashioning state-centred energy policy programs aimed at improving energy security and decreasing dependence on outside energy sources (Flynt Leverett & Jeffrey Bader, 2005; Shaffer, 2011). In 2007, both the United States and the European Commission published energy independence and security policies detailing energy challenges and outlining broad policy options for a comprehensive energy security

strategy (Belkin & Morelli, 2007). In the European Union, energy policy has recently become an important point on its political agenda. As the European Commission put it:

The energy challenge is one of the biggest issues facing Europe today. The prospect of sharply rising energy prices and increasing dependence on imports makes our energy supply less reliable, and jeopardises the whole economy. (European Commission, 2013)

1.2 EMERGING WIND ENERGY SCENARIO

A major solution thought to alleviate the energy crunch is the development of alternative energy sources, such as wind power, hydropower, geothermal energy, solar energy, biomass and biofuel. Wind power is arguably the most developed of these alternative energy sources, having emerged as a positive source of alternative energy already following the oil crises of the 1970s, and thus benefits from three decades of technological development (Norberg-Bohm, 2000). Today, the lessons learned from more than a decade of operating wind power plants, along with continuing R&D, have made wind-generated electricity very close in cost to the power from conventional utility generation in some locations. Central in this development has been steady increase in average turbine size over the past 30 years, as demonstrated in *Figure 5*.

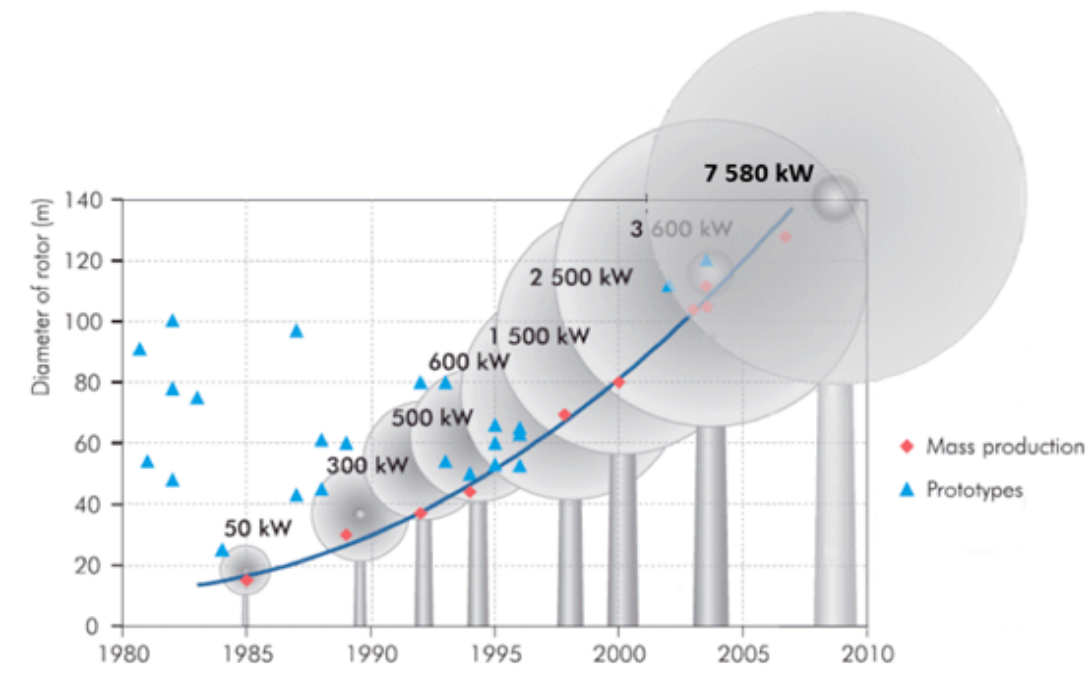

Figure 5: Size and Power Evolution of Wind Turbines over Time (Source: International Energy Agency)

The technological development in wind power has brought the costs down: for example, the costs of electricity generated from wind power fell to about one-sixth at the turn of the millennium from what it was in the early 1980s (Neij, 1999). Hence, wind power can be considered to be the most viable of renewable energy options because of its lower costs. This is reflected in the fast growth of installed wind power capacity, as demonstrated in *Figure 6* and *Figure 7*.

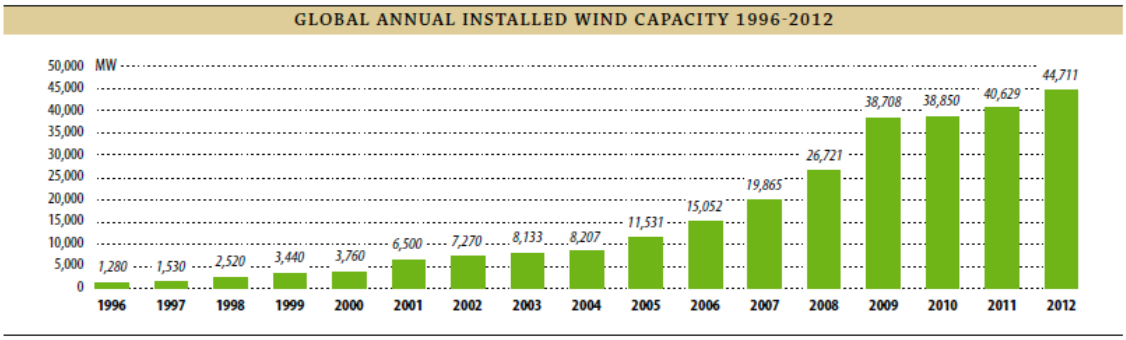

Figure 6: Global Installed Wind Capacity (Source: Global Wind Energy Council, 2013)

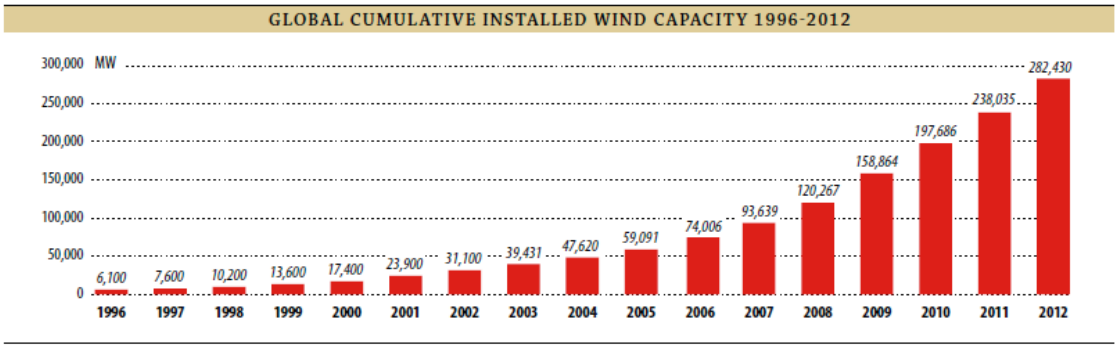

Figure 7: Global Cumulative Installed Wind Capacity (Source: Global Wind Energy Council, 2013)

Growth has also been further fuelled by the so-called energy race between the United States, China, and the European Union. As of 2013, the European Union, the United States, and China are neck-to-neck in wind power development, as shown in *Figure 8* (Global Wind Energy Council, 2013).

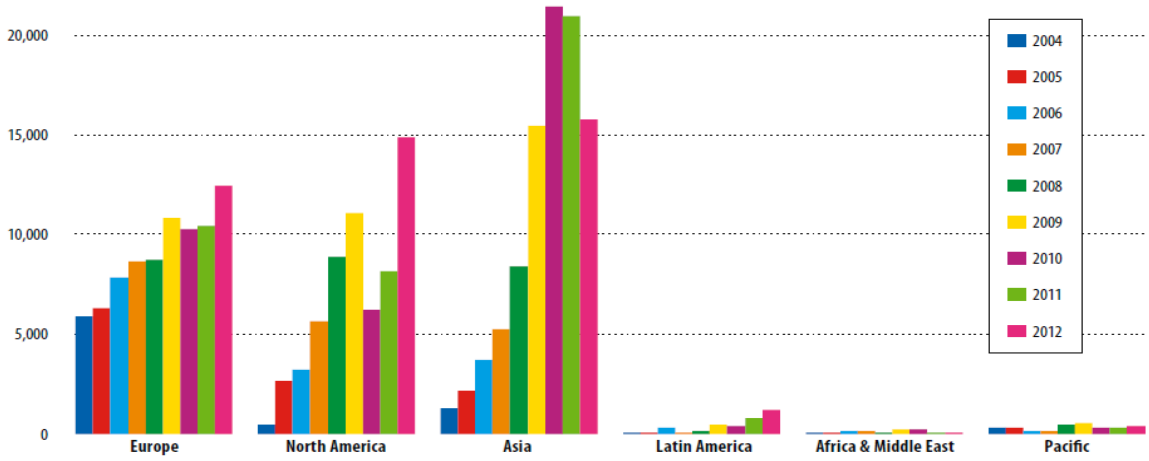

Figure 8: Annual installed wind energy capacity by region 2004-2012 (source: Global Wind Energy Council, 2013)

Moreover, wind power is already becoming a real force in the energy market, accounting for a considerable 11% of European Union energy needs in 2012, significantly up from 2% in 2000.

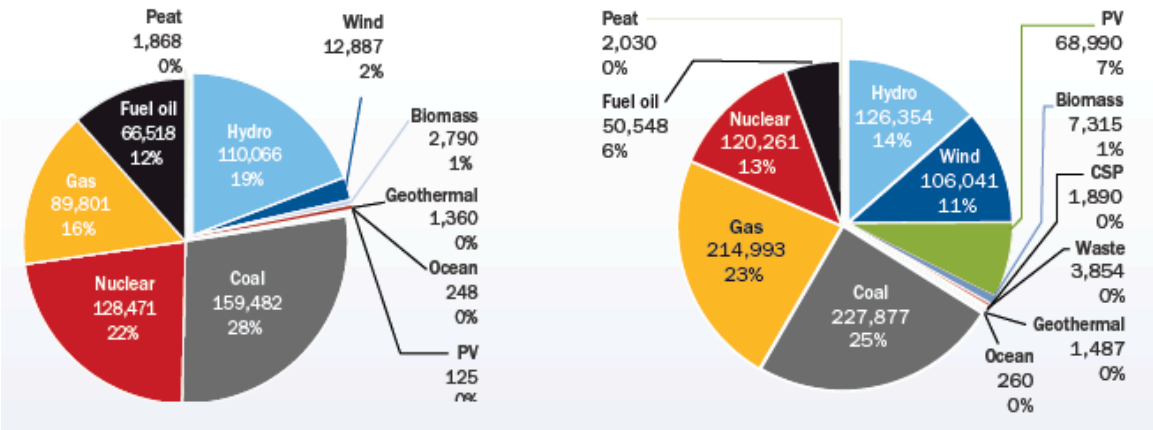

Figure 9: EU Power Mix 2000 and 2012 (source: EWEA The European Wind Energy Association, 2013)

The long-term demand for wind energy is likely to stay on the political agenda, encouraging and mandating private firms to invest in wind energy developments (Díaz Anadón, 2012; Hitaj, 2013; Islama, Mekhilef, & Saidura, 2013; Pettersson, Ek, Söderholm, & Söderholm, 2010). Promotion of Danish wind power in the last three decades does exemplify how an industry with related clusters can be successfully built by government policy (Pettersson et al., 2010). However, although policy instruments can do much to shape and influence industries, they cannot perform miracles. For that reason, the future of wind power will depend on the ability of the industry to continue to achieve cost reductions. Over the past 30 years, the cost of wind energy has significantly decreased, due to both capital cost reductions and performance improvements. However, from roughly 2004 to 2009, continued performance increases were not enough to offset the sizable increase in capital costs of this time period, resulting in an overall increase in the cost of wind energy. Nevertheless, as capital costs have moderated from their 2009–2010 levels, the cost of wind energy has fallen and is now at an all-time low within fixed wind resource classes. Nevertheless, the levelized cost of energy (LCOE) should continue to fall on a long-term global basis. Most recent estimates project that the LCOE of onshore wind could fall by 20%–30% over the next two decades. (Lantz, Hand, & Wiser, 2012) Even if the figures fall short of these estimates, it appears imperative that wind power costs must continue to drop for the technology to be competitive, possibly even without government subsidies.

1.3 Continuous Innovation in Wind Energy

A large number of technological and market-based drivers are expected to determine whether projections of future costs are ultimately realized. Indeed, numerous innovations ranging from purely technical ones to manufacturing process improvements and logistical solution innovations. Particularly desired are innovations that can increase wind power energy generation capacity and/or lower costs of generating wind power. However, implementing innovations into markets is highly challenging, because in a wind energy project, so many components must come together to form a seamless

whole, as illustrated in *Figure 10*. Indeed, value chain management has become central to the competitiveness of wind energy projects. Wind power industry value chain is complex and non-linear, where components are assembled together to erect a wind turbine. There are approximately 16 major components in a wind turbine, which together contribute close to 90% of the cost of a turbine. *Figure 10* illustrates the main components that go into a wind turbine.

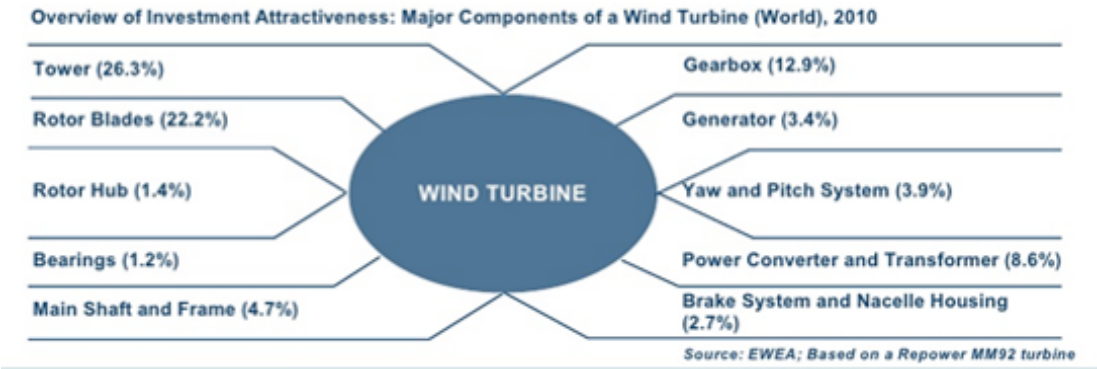

Figure 10: Wind power main components (source: EWEA The European Wind Energy Association, 2013)

Moreover, beyond the immediate technological value chain, there is also another supply chain, one that wind turbine manufacturers must be able to handle in order to reach successful project outcomes. This is demonstrated in *Figure 11*.

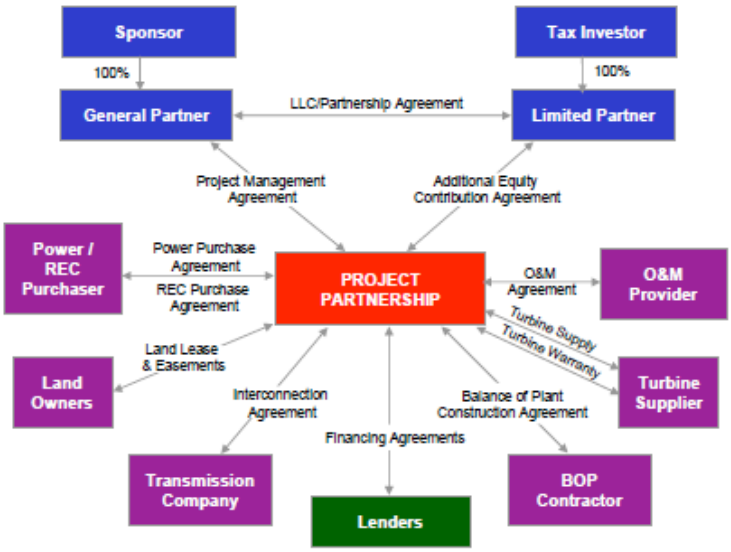

Figure 11: Operating structure of a typical wind project (source: EWEA The European Wind Energy Association, 2013)

Understanding this complex, non-linear innovation environment that is highly cost-conscious may well be done using continuous innovation theory (Boer & Gertsen, 2003; Chapman & Corso, 2005; Hyland & Boer, 2006). Continuous innovation may be seen as an organization's capacity for timely responsiveness and rapid product innovation,

coupled with the management capability to effectively co-ordinate and redeploy internal and external competencies (Bessant, 2002; Teece & Pisano, 1994). In other words, an organization must engage in constant learning and innovation, but combine this strategic flexibility with operational effectiveness (Boer & Gertsen, 2003). This is quite precisely what companies in the wind energy industry must do, although it is by no means an easy feat, as an organisation attempting to continuously innovate will experience significant tensions as it tries to innovate and maximise operational performance (Hyland & Boer, 2006). The multiplicity of interactions and interplays that exist for organisations attempting to achieve long term viability by strategically balancing operational effectiveness and innovation activities can be daunting (Hyland & Boer, 2006) – however, to succeed in business long-term, major players in the wind energy industry must do this.

Intriguingly, while there is much technological, manufacturing, and logistics innovation going on in the wind energy industry, the most profound innovation dynamics going on currently are those of business models. The power players in the industry – the wind turbine manufacturers – appear to be polarizing into two camps, each with its own preferred business model. The first of these business models is to reduce uncertainty in component supply through vertical integration, a business model pursued by firms such as Enercon, Gamesa, and Suzlon. The second of these business models is to reduce uncertainty through long-term, close partnerships with suppliers, a business model chosen by firms such as GM, Vestas, and Siemens. Firms in both camps are apparently aiming at the twin demands of strategic flexibility and operational effectiveness, but pursuing it through different business models (Lindgren, Taran, & Boer, 2010). In a way, what we see here being empirically played out is a competition between business model innovations, where in one the goal is to develop *intra-company* continuous improvement and in another one the goal is to develop *inter-company* collaborative innovation between members of an extended manufacturing enterprise (Chapman & Corso, 2005). This continuous innovation literature has many meeting points with the fashionable open innovation (Chesbrough, 2003, 2006) and co-creation concepts (Prahalad & Ramaswamy, 2004). Although they differ in nuances, all three theoretical concepts endorse a move from isolated organizational actors to co-operating networks of companies. However, all of these theoretical perspectives are quite incipient and do not therefore provide mature theoretical frameworks for the analysis of empirical data. Therefore, the core notion that the boundaries between a firm and its environment are quite permeable – and should be so – in order for innovations to be developed and commercialized successfully, is used as a theoretical perspective in this paper, classified as less developed than a theoretical framework would be.

2. RESEARCH QUESTIONS AND METHODOLOGY

2.1 RESEARCH QUESTIONS

Wind energy is the world's fastest-growing energy source with rapid technological development. As such, it should be particularly open to new innovations, as it needs to continuously innovate to simultaneously improve technological performance and bring costs down. The empirical study examines how business model innovation into a network-based model may be accomplished at a manufacturing company commercializing a new wind power tower structure. The innovation in question is a new type of a tower structure for a wind turbine, which has the advantage of raising the turbine to greatest heights, which in turn enables greater power generation efficiency. Although a wind tower is not the first thing that comes to mind when thinking about

innovations in wind energy, as its impact on system performance is quite small, it can represent more than 25% of the total WTG (Wind Turbine Generator) cost, as illustrated in Figure 2. This makes tower innovation a relevant area for cost optimization, and in this particular case, is likely to improve energy yields as well. The innovation being commercialized is a wind turbine tower solution that enables hub heights from 100 to 160 metres. As wind velocity increases with height, higher towers are more efficient and can also benefit from inland wind conditions. Reaching better wind conditions leads to higher average power and full load hours, and consequently also to a higher return on investment combined with the lowest life cycle costs. The tower innovation is illustrated below.

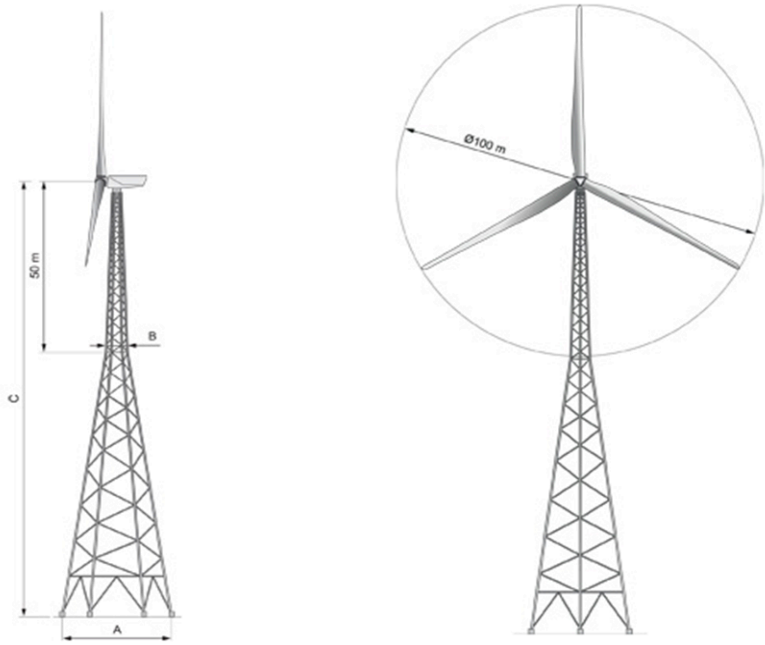

Figure 12: The tower innovation (source: the case company)

However, in the case examined here, a wind power tower innovation has not been adopted into the wind power industry, despite its many clearly superior technological features vis-à-vis competitors. Therefore, the research questions posed in this paper are:

- *RQ1: Why has the wind power tower innovation not been adopted by the relevant market actors?*
- *RQ2: What could be done to convince the relevant market actors to purchase a wind power tower innovation?*

2.2 METHODOLOGY

The methodology used to answer the research questions posed above is that of a theory-building case study (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). Building theory from case studies is a research strategy that involves using one or more cases to create theoretical constructs, propositions and/or midrange theory from case-based, empirical evidence (Eisenhardt, 1989). Case studies are rich, empirical descriptions of particular instances of a phenomenon that are typically based on a variety of data sources (Yin, 2003a, 2003b). The central notion is to use cases as the basis from which to develop

theory inductively. The theory is emergent in the sense that it is situated in and developed by recognizing patterns of relationships among constructs within and across cases and their underlying logical arguments. Hence, in this study, a single case was approached in an exploratory manner, where no strict a priori hypotheses had been formulated prior to the start of data gathering, but the theoretical background instead functioned to sensitize the researcher in terms of what to pursue in data gathering and which findings were interesting. The methodology employed in the study was that of a single explorative case study (Yin, 2003a, 2003b), which is an ideal methodology when a holistic, in-depth investigation is needed. Case studies are multi-perspectival analyses. This means that the researcher considers not just the voice and perspective of the actors, but also of the relevant groups of actors and the interaction between them. A case study is not generalizable in the same way that a statistical study is, as it aims instead at analytic generalization. In analytic generalization, previously developed theory is used as a template against which to compare the empirical results of the case study (Yin, 2003a, 2003b).

2.3 Data Collection and Analysis

Data was collected through semi-structured interviews with ten experts familiar with the wind power technology innovation and the market environment into which the company wished to launch it. The interviews were all conducted with individuals external to the company because the aim was to gain insights into how the markets viewed the innovation. This was because the individuals within the company developing and commercializing the innovation were puzzled by the lack of success in commercializing the innovation, because they were so familiar with its technical features which appeared superior to competing products at least on paper. Therefore, the aim in data gathering was to collect outsider views to try to figure out how the technological innovation could be commercialized more effectively. The interviewed experts are listed in the following table. The interviews were all conducted during fall 2011, both face-to-face and by telephone. Most of the interviews were recorded and transcribed, but some of the interviewees were so concerned about their anonymity and the confidentiality of what their were saying that they refused to have the interview recorded, in which case the analysis presented here relies on notes taken during the interview. Moreover, as the interviewees often had dealings with the company whose innovation was being researched, they were adamant that neither their company nor their position within it could be mentioned. Hence, the table below simply lists the types of interviewees.

Interviewee #	**Position type**
1	Industry expert at a consulting company
2	Industry expert at a consulting company
3	Industry expert at an international trade association
4	Industry expert at an investing company
5	Representative of a potential customer company
6	Representative of a potential customer company
7	Representative of a potential customer company
8	Representative of a potential customer company

9	Representative of a potential collaborating company
10	Representative of an industry organization

2.4 FINDINGS

The interviewees all agreed that the push factors for the commercialization of the wind power tower innovation were those delineated by the developing company. In other words, the tower solution was agreed to be technologically superior to many competing solutions. Especially the increased tower height was determined to be the main competitive advantage in commercializing the innovation, together with the modularity of the solution which provided ease of transporting the tower. However, resistance factors for innovation commercialization came to form the main substance of the interviews, as the interviewees noted that although the solution was in many ways technologically superior, there were several factors which impeded its successful commercialization. These resistance factors pointed out by the interviewees are presented next, grouped under the main topics with details under each topic.

1. Fear of risk due to lack of demonstrated use experience
There is a lack of demonstrated use experience with the tower solution that would prove that the solution really works and is effective
References of experience in using the solution are lacking especially from northern conditions
Currently used tower solutions are less risky because there is a long track record of use experience, also in northern conditions
Lack of use experience and references creates uncertainty and makes the decision of purchasing the tower solution seem highly risky
Some interviewers wished for as much as 10 years of demonstrated successful use experience, especially in northern conditions, before they would purchase the tower solution

2. Perception of solution not being ready and doubts about its effectiveness
The interviewees were not entirely convinced that the technical solution is mature and that it works properly and effectively
Northern conditions were seen to be especially challenging for this tower solution, and this creates uncertainty about how well the solution would work
Interviewees were not entirely convinced of the dependability of the lattice structure of the tower
Interviewees were not entirely convinced that the solutions the innovating company had provided to prevent and fix any such problems resulting from these challenges would truly work and would be dependable
Interviewees had also witnessed the innovating company exhibiting new technical developments to the tower solution at industry fairs, which gave the perception that the technical solution is not entirely ready and mature yet

3. Price indications

The price is considered to be quite high for the solution to bring enough cost savings to the customer
Nearly all interviewees expressed a wish/expectation that the price would come down
The price was also expected to come down as competition in the area would increase

4. Regulatory restrictions
Although the greater height of the tower solution is an advantage, it is also a problem because of current regulatory restrictions
As currently 140 metres is the allowed maximum height for wind towers in many countries, the height of this solution begins to be problematic
There are several public authorities setting restrictions to wind towers currently, which makes negotiations about towers with greater height complex

5. Public opposition
The greater height of the tower solution creates greater local public resistance to the wind tower because a taller wind tower creates a greater visual disturbance, and this tower solution is very visible
The greater height of the tower also requires more effective flight alert lights which also disturbs local people living in the proximity of the tower more than less effective lights would – this easily leads to complaints and resistance from the people in the area already in the planning stage
People are often afraid of new things, there is quite a lot of resistance to them; when the height of the tower is greater, the fear and resistance are even greater
As people are more used to the traditional wind tower structures, they may also resist this alternative structure more because they think it looks uglier than the traditional structures

6. Fear of a 'triangle drama'
Not all turbine manufacturers have approved this tower solution yet, which creates uncertainties and restrictions
Some interviewees expressed fear that buying the tower and the turbine from different manufacturers would result in more complicated relations than buying an integrated tower & turbine solution from a single manufacturer
There was a fear expressed that the involvement of three parties in the production could result in a "triangle drama"
Responsibilities and guarantees would be less clear when two solution providers (tower provider and a turbine manufacturer) would be involved, whereas if only one integrated solution provider were involved, things would be more straightforward
It was perceived as possibly risky that in case something went wrong with the entire tower & turbine solution, all three parties (tower provider, the turbine provider, and the customer) would be blaming each other and nobody would take responsibility

3. CONCLUSIONS AND DISCUSSION

The findings concerning resistance factors to the wind power tower solution innovation were for the most part quite expected as such fears and misgivings are common when

commercializing innovations. Especially in this context where investments are sizable, regulation is heavy and complex, and the innovations are highly visible to the public at large, most of the restrictive factors are to be expected. Moreover, it is almost with any innovation that there are doubts concerning its functionality as long as there is little or no demonstrated experience, and many individuals are keen to wait for the price to come down as it typically does when technology matures.

However, a less expected and interesting finding was the fears of a 'triangle drama' if a customer, i.e. an electricity company, were to purchase the wind power turbine and tower from separate companies. This finding is particularly interesting when reflected against the theoretical framework used in this paper, which emphasizes business model innovation toward more open innovation and co-creation modes. Specifically, what the tower innovation producer is trying to do is to disrupt the accepted business model structures of the wind power industry. The current traditional business model in the wind power industry is one where a single company produces and delivers both the turbine and the tower to a customer. The company in question here, which is aiming to commercialize a new tower solution without being a turbine manufacturer, is thus disrupting the industry structure and accepted way of doing things by trying to introduce a new business model into the industry. By doing this, it is challenging companies that manufacture both turbines and towers, but also creating additional uncertainty and doubts among potential customers: to the usual fears of new technology are now added extra fears of adopting a new way of doing business. It may be that this business model innovation, although apparently unintended by the company, may be the more revolutionary innovation than the actual technological tower structure. If this is the case, then much of the resistance the company trying to commercialize the new wind power tower solution may not be entirely due to the novelty of the technology itself, but to the way the company is trying to bring this technology to market. In this case, the best move this company could make is to take its business model innovation all the way through to a collaborative one which emphasizes open innovation and co-creation.

Nonetheless, it is unlikely that a value chain partner would be likely to commit to a close, long-term partnership with the case company without a real-world, extended proof of concept. Here a growing, but little understood area of government involvement in promoting renewable energy through the use of demonstration trials (DTs) as a policy tool could be highly useful. Although government-sponsored DTs have not proved to be miracles, they have had a major benefit of 'learning by using' for stakeholders relevant for the value chain (Harborne & Hendry, 2009). Therefore, they can be seen as an extension of the prototyping process into next phases of development and are widely used in reducing uncertainty for new technologies. There is still relatively little attention to this 'uncertain middle' phase in accelerating complex, large-system innovation, particularly as to what companies actually value, as distinct from what advocates suggest they should gain and what policy makers believe publicly funded DTs should achieve (Hendry, Harborne, & Brown, 2010). However, as this explorative study indicates, more attention should be paid to demonstrative trials, as they help to overcome the excessive uncertainty related to technological innovations that need to become a symbiotic part of a complex system. Finding ways in which companies could better demonstrate the actual use value of their products, services, and solutions could also be useful in business model innovation toward more collaborative, networked models, as it would enable organizations to better demonstrate and assess each other's offerings.

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