ISBN 978-82-326-1300-7 (printed ver.)
ISBN 978-82-326-1301-4 (electronic ver.)
ISSN 1503-8181

Marius Korsnes

Doctoral thesis

Doctoral theses at NTNU, 2015:322

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Chinese Renewable Struggles

Innovation, the Arts of the State and Offshore Wind Technology

NTNU
Norwegian University of
Science and Technology
Thesis for the Degree of
Philosophiae Doctor
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Printed by NTNU Grafisk senter

Acknowledgements

Although my name is on the title page of this dissertation, the thesis is an outcome of the inputs from many people and things. I wish to thank everyone who supported, helped, comforted, enlightened, pushed, dragged, and taught me during the past three years of working with this dissertation. Linsu Kim says in his book about Korea's technological catch-up that: 'As long as Hyundai manages to construct and resolve crises […], it will remain a contending Korean automobile producer' (Kim 1997, p. 129). Constructing and resolving crises sounds like a winning recipe, also when it came to completing this thesis.

On the one hand, the increasing amount of knowledge, information and general research available to researchers can make it easier to write. On the other hand, it gives a sensation of an endless river of input in which you either drown or drift away, or you turn your back to it and run. Luckily PhD students have navigators, guiding stars and lighthouses that bring you safely across the river. The three main advisors for this thesis have been Gard H. Hansen, Marianne Ryghaug and Knut H. Sørensen. A big thanks to all of you for your tremendous support during these three years.

I also wish to thank all those who helped me during my one year in China: Colleagues and friends at the Shanghai Jiaotong University, my interpreters, the participants of the 2013 CICALICS in Beijing, particularly Professor Andrew Tylecote, participants and organisers of the Shanghai Social Studies Colloquium, and all friends I was happy enough to encounter during the stay.

I wish to thank everyone at the department of interdisciplinary studies of culture at NTNU for all your support, debates and discussions during these three years. I hope to continue these exchanges in the future! In particular, my office buddy William and his unique ability to always say the right things was highly appreciated in the writing-up phase of the thesis.

Lastly, thank you to my friends and family that have supported and encouraged me this whole time!

Happy reading!

Trondheim, June 2015,

Marius Korsnes

Contents

Introduction

The transformation that is taking place in the People's Republic of China (hereafter China) is unrivalled in history. China's economy has grown faster for a greater length of time than has any other country (Naughton 2010a), and this has had a major impact on China's population, which amounts to almost one-fifth of the global population. The reform that started under Deng Xiaoping in 1978 has affected every aspect of life in China, from individuals, families, societies, governments and international relations to environmental decay, pollution, greenhouse gas emissions and the destruction of natural resources (Saich 2011; Shapiro 2012). These changes have opened the country to opportunities and threats from actors outside of China (Altenburg 2008) – opportunities relating to China's alluringly large market and threats arising from the potential loss of market position for established companies. There is, therefore, something of a scramble to make the best of the opportunities and to limit the threats. The Norwegian government has also realised this, and has a stated ambition to cooperate with China, as testified in the 2007 'The Government's China Strategy'.[1] The Norwegian government especially focusses on the environment, climate change and sustainable development. Under the headline 'Norwegian technologies may help solve China's environmental challenges', the Norwegian embassy in Beijing stated in 2014 that:

> As a result of the increasing pollution and tightened environmental regulations, the water and waste handling industry in China is seeking leading technologies from abroad to help solve China's environmental challenges. Norway has much to offer. (Norway.cn 2014)

China is seeking and Norway can offer. There is clearly an interaction between Norwegian and Chinese actors, but who is seeking and who is offering in this relationship? Are Norwegian companies offering help or seeking new markets? Are Chinese actors seeking or offering help? China is undoubtedly becoming more interesting not only to Norway, but also to the rest of the world. Conversely, the rest of the world is becoming more interesting to China. But how do experiences, knowledge and technology journey across borders?

[1] https://www.regjeringen.no/nb/dokumenter/kina_strategi/id477509/ (accessed 19.03.2015).

This dissertation examines the offshore wind industry in order to better understand the ways in which innovation and technological learning happen and can be understood within one branch of China's renewable energy industries. Using this industry as a case, the thesis may also shed light on innovation processes more generally in the context of China. Innovation is here viewed broadly, incorporating interactive learning and circulation of knowledge, competencies, experiences and expectations connected with offshore wind technology. A wide definition of innovation allows for an analysis of offshore wind technology that is not only limited to the technology itself, but also amongst other things includes societal, economic, environmental and political aspects. The thesis attempts to show how innovation and learning are processes imbued with politics. The innovation process is embedded in complex transactions and translations and negotiations of power, pride and culture that transcend the technology – here, offshore wind turbines. In other words, this thesis is concerned with the business and politics of offshore wind technology development. The main research questions are therefore: How does China's offshore wind technology development unfold, and how can this process be understood and conceptualised? In the process of exploring this question, several related questions arise: Who are the central actors that define the way in which the industry develops, how do these different actors influence the development of China's offshore wind industry, and what role does the European offshore wind experience and knowledge play in this development? In other words, this overview and tie-up essay sets out to provide both empirical and theoretical insights from China's (and my own) engagement with offshore wind technology development.

The theoretical point of departure in this dissertation is the understanding that technological development is a product of the interactions and dynamics between a heterogeneous set of actors, technologies and objects (Bijker et al. 1987; Sørensen & Williams 2002). In general, this implies a certain curiosity as to who and what may be regarded as important or not within innovation processes. It is increasingly acknowledged that technological and industrial development do not take place in closed geographical systems, but are the result of cross-border encounters and the mutual learning processes of both international and local actors (Hansen 2009; Nahm & Steinfeld 2014). This is especially evident in China, where foreign technology has contributed substantially to industry development over the past 30 years, and it is also the case for China's wind industry. In these processes of what has been seen as technology transfer, diffusion or catch-up, it is easy to lose sight of who does what, and how. Is technology merely transferred or diffused to China?

Rather than following this line of thought, we can ask: Who are the promoters of such diffusion? Who are the actors that strategically work to build offshore wind technology in China, and what type of knowledge and experience do they make use of? Hence, this overview and tie-up essay critiques the way in which technological learning in latecomer countries has been conceptualised through 'technology transfer' and 'catch-up'. What is needed instead, I hold, is a critical view of how innovation and technology development can be understood in a Chinese context. By introducing and discussing two different perspectives on innovation and social change, namely innovation systems (IS) and science and technology studies (STS), I intend to bring more detail to the discussion of what innovation can mean in a Chinese context. The interesting debate that these two perspectives generate is that whilst IS has a rather fixed idea of what the essential ingredients of innovation are, STS questions the assumption that there exists a blueprint that in any certain way can point towards innovation. I will return to this discussion towards the end of this overview and tie-up essay.

From a Chinese perspective, there is an increasing focus on becoming more independent from foreign firms. In practical terms, as Chinese firms learn new technologies, this means that they can 'collect rather than pay royalties and license fees' (Kroeber 2011, p.63). This strategy is manifested in what is translated as the 'indigenous innovation' programme, which, amongst other things, involves financial incentives for developing high-technology products, building a larger base of national intellectual property and standards and compelling foreign companies to reveal their commercial secrets (Kennedy 2010; Cao et al. 2009). However, the reduction of technology dependency does not appear to reconcile with China's obvious interests in attracting and learning new technology and experiences. By studying the interactions between a heterogeneous set of offshore wind industry actors from inside and outside China, this dissertation aims at understanding who the protagonists and antagonists are in innovation processes in China's offshore wind industry.

Offshore wind technology is relatively new and may be considered an emerging technology (Heidenreich 2014). Emerging technologies are defined as technologies that are in 'the developmental stage of production (…) or in the early stages of commercialisation' (Einsiedel 2009, p.3). At the end of 2014, Europe had more than 8,000 megawatts (MW) of installed offshore wind power across 74 wind farms, and the first wind turbine was installed offshore in 1991 in Denmark (EWEA 2015). In China, there is currently about 670 MW of

power across mainly two offshore wind farms, and the first turbine was installed in 2006 in Bohai Bay outside of Beijing (GWEC 2015). As an emerging industry, the offshore wind industry provides a unique opportunity for the study of innovation processes where institutions are still in their infancy. Moreover, as of 2015, China was by far the largest investor in new renewable energy (FS-UNEP 2015). The success or failure of China's offshore wind industry may indicate the prospects of a potential renewable energy transition in China and provide lessons for other countries.

The offshore wind industry can, in many ways, be understood as an offspring of China's onshore wind industry. In only around ten years, China conditioned the growth of onshore wind turbine manufacturing and deployment at a scale and pace never before witnessed. Today, the Chinese wind industry produces more wind turbines than any other country, Chinese companies dominate the list of the world's largest wind turbine manufacturers and China has the largest installed capacity of wind energy globally (REN21 2014). Starting with the wind concession programme in 2003, China's wind industry grew to an installed capacity of 114,763 MW at the end of 2014 (GWEC 2015). In 2013, this capacity generated 140 terawatt hours, which amounted to 2 per cent of the total electricity generation in China (Pengfei 2014). As shown in Figure 1, the wind industry has grown almost exponentially since 2006.

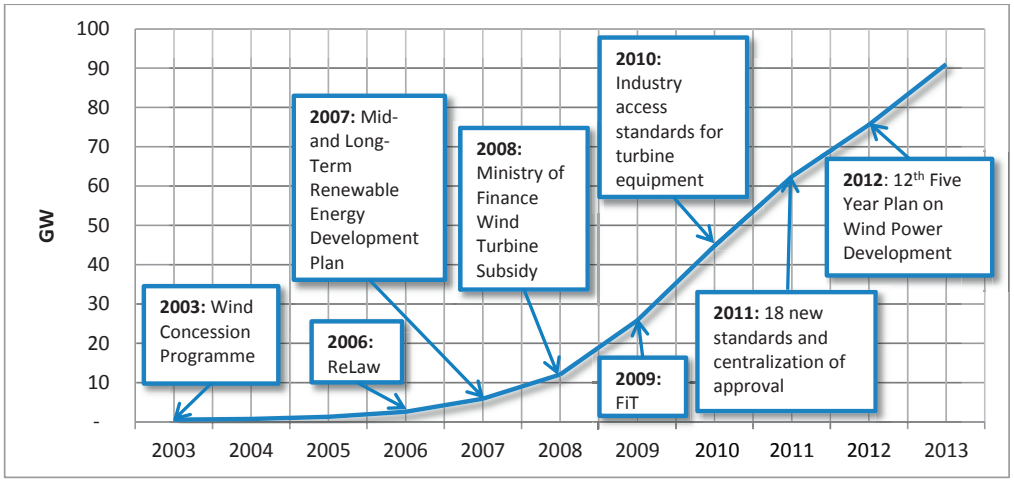

Figure 1: Installed wind power capacity and policy development in China, 2003–2013

Source: Ydersbond and Korsnes (2015)

The advantages of a domestic wind turbine manufacturing industry were perceived to be numerous. In addition to the 'indigenous innovation' concern, the Chinese government's goal from the outset was not only to accelerate the development of wind farms, but also to create a cheaper option than reliance on imported turbines (Howell et al. 2010; BNEF 2010). Between 2006 and 2011, the industry created an estimated 200,000 direct jobs (Pan et al. 2011), contributing to a substantial increase in China's proportion of renewable energy jobs. China has much experience in manufacturing; therefore, it seemed perfectly natural for the nation to attract the wind industry, as China has attracted industry after industry since the beginning of the reform period in 1978 (Kroeber 2011). In 2010, China's renewable energy industry (including solar, wind and biomass energy) was one of seven new strategic emerging industries the Chinese government named to help advance economic development, foster innovation and promote domestic technologies (CGTI 2011). According to this plan, an estimated US$ 231 billion would be invested exclusively in wind power between 2011 and 2020 (Pan et al. 2011). A much stronger government support signal than this is hard to find in China; thus, renewable energy is one of the most important industries in the country (Medland 2012; Christensen 2013; Nahm 2014).

The energy provided by offshore wind in China is particularly interesting since most Chinese live along the east coast, where wind farms can be built. China's southeastern coastal areas are the fastest growing and have very few energy resources of any kind (Naughton 2007), apart from offshore wind energy. China has delved head-on into the offshore wind industry, yet with a troubling start. In 2010, China initiated the first concession round for offshore wind farms; four projects were commissioned in Jiangsu province, totalling 1 GW of installed offshore wind power capacity (Zhang et al. 2011). In this concession round, all of the developers and turbine manufacturers were Chinese domestic actors. Shortly after, however, these projects underwent new environmental assessments and cable routing, and it was decided that the project sites would be changed; this led to considerable delays and higher costs (Li et al. 2012). Nevertheless, based on their experiences with the onshore wind industry, many of the largest wind turbine manufacturers began to invest in offshore wind technologies.

As Map 1 shows, only two offshore wind projects were completed by the end of 2013: Donghai Bridge near Shanghai and the Rudong intertidal projects in the intertidal areas of Jiangsu province (4coffshore 2013). China's first major offshore wind farm was the Donghai Bridge 102 MW project, and was completed in 2010. Since the first turbine was tested there in 2009, phases 1 and 2 of the Rudong intertidal wind farm have been constructed, now totalling 232 MW (ibid). Remaining projects are mostly one-off installed turbines for demonstration purposes. According to data from the World Wildlife Fund (WWF 2010), the strongest winds are in the Taiwan Strait off the coast of Fujian, followed by Zhejiang and the west coast of Hainan. Guangdong also shows significant potential. WWF (2010) states that, over the past 50 years, 'Guangdong has had the highest occurrence of typhoons with approximately 160 typhoons coming on land'. The adverse effect that typhoons have on wind farms is a technical challenge that needs to be overcome in order to fully develop typhoon-prone provinces. The occurrence of typhoons makes Shandong and Jiangsu provinces more attractive for development at the present stage.

Map 1: China's coast and Offshore Wind Farms end 2013

The thesis is structured as follows. In the next section, I will give a brief overview of the four papers in this dissertation. These papers can be read in their entirety after this overview and tie-up essay. I will then, in the section named 'Chinese energy governance and indigenous innovation', explain some central facets of China's energy sector and the way in which innovation has been theorised and discussed in a Chinese context. The section provides a background for the following theoretical and analytical discussion in this

overview and tie-up essay, as it attempts to situate the existing discussion on innovation in China. I then go on to describe the literature on technological learning and catch-up in latecomer countries, in order to determine whether these frameworks are useful for the study of China's offshore wind industry. Finding that successful catch-up boils down to successful learning and innovation, I suggest that theories of innovation may be equally if not better equipped to use as guiding frameworks to understand the development of China's offshore wind industry. Therefore, I then outline the innovation systems (IS) literature with a specific emphasis on perspectives of technological learning. Concluding that the IS literature is useful, but lacks certain aspects that relate to the politics involved in innovation processes as well as conceptualisations of change within a system, I continue with an introduction of science and technology studies (STS) perspectives of innovation.

The two perspectives chosen from STS is the 'sustainability transitions' framework, and actor-network theory (ANT). The sustainability transitions framework is introduced for three reasons: 1) although inspired by the systems of innovation approach in ontology, it provides a different conceptualisation of change and how transitions can occur within an established regime. This is relevant if we understand the emerging Chinese offshore wind industry as a potentially disrupting force that could one day replace the coal-based Chinese electric power system. 2) It provides a novel way of thinking about how the government acts as a supporting force through sustaining niches. This is important given the central role of the Chinese Communist Party in Chinese politics and governance, and the offshore wind industry understood as a niche within the established electric power system. 3) It is based on a particular effort to create transitions towards more sustainable regimes. This is relevant because offshore wind technology is a renewable energy source that we can consider more environmentally sustainable than coal power.

Next, actor-network theory is introduced in an effort to highlight innovation from a perspective that does not take established institutions as a point of departure. This I find necessary because the premises of ANT is that we should not take anything for granted, and let ourselves be taken by surprise of the potentially important influencing factors in how offshore wind technology in China unfolds. ANT focusses on processes and actors that assemble, mobilise and circulate knowledge and materials that pave the way for innovations to occur. The theory emphasises that technology is constructed, locally negotiated and concomitantly emergent with its environment. ANT asks what goals are attempted to be

achieved, how this happens and who the involved actors are that benefit from different actions. This may help to uncover new and unexpected actors (human and non-human) that were not evident when for instance using 'Western' goggles, or a particular set of institutions and organisations.

My ambition when introducing these different perspectives is not to create a unified theory of innovation, but rather to understand innovation processes by employing different lenses that, together, may assist in providing a richer description of the development of offshore wind technology in China. Following the section on STS perspectives on innovation, in the section named 'Cross-cutting analysis: Creating a world after whose image?' I discuss these theories and the way in which the papers of this thesis may inform new aspects of innovation within the context of China's offshore wind industry. I then provide some concluding thoughts before explaining the methodology. Lastly, the four papers will be presented.

Overview of papers

The story of how offshore wind technology unfolds in China starts with the onshore wind industry and China's ambition to increase the base of renewable power in their electricity mix. Globally, renewable energy sources are dependent on policy support in order to compete with traditional energy sources and their growth hinges on continued political prioritisation (REN21 2014). The success of renewable energy industries therefore gives the government a more direct role. In China, there is a large and growing base of renewable energy technologies. From these growing industries, several insights can be gained into the Chinese Communist Party's attempts to orchestrate the development. Paper 1, 'Fragmentation, Centralisation and Policy Learning: An Example from China's Wind Industry' takes this as a starting point and examines the governance of China's onshore wind industry. Paper 2, 'Limits to Interactive Learning: Ensuring Quality in China's Emerging Offshore Wind Industry' addresses the offshore wind industry, and looks at technological learning and quality considerations. Paper 3, 'Outside the European Box: China Developing Offshore Wind Technology' examines more in detail how knowledge and experience from Europe influences offshore wind technology development in China, and paper 4, 'Ambition and Ambiguity: Expectations and Imaginaries Developing Offshore Wind in China' explores how the future is used as a resource for creating a protected space

for offshore wind technology in China. The four papers included in this dissertation are numbered as appears in Figure 2. Ideally, these four papers should be read before this overview and tie-up essay. Next, I shall therefore elaborate briefly on the contributions of each of the four papers.

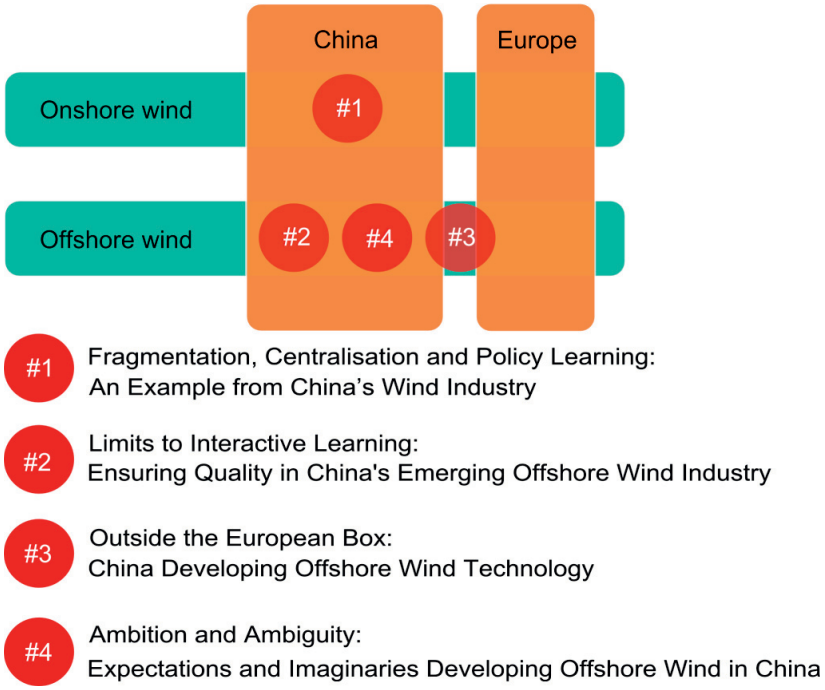

Figure 2: Overview of the papers

Paper 1, 'Fragmentation, Centralisation and Policy Learning: An Example from China's Wind Industry' addresses the dynamics of change within China's energy sector and shows the way in which the Chinese government has mobilised and accommodated the growth of a domestic wind industry. The paper illustrates that flexible governance has allowed for rapid growth while also ensuring that overcapacity does not lead to collapse. Fragmentation and centralisation are important features of the flexibility that the Chinese government has drawn on. Fragmented authority means that there are several concentrations of power in China, such as various central government ministries, local and provincial governments, state-owned enterprises (SOEs) and private firms. Centralisation occurs when the very apex of the Chinese Communist Party, typically the standing committee (consisting of the seven most influential people in the party), intervenes directly to make a decision. The contribution of this paper is a better understanding of the mechanisms of policy learning and

the workings of fragmentation in China's onshore wind industry. The paper highlights the important role of policy experimentation in the coordination of interests as part of the policy learning process. This is exemplified by the wind project concession rounds between 2003 and 2007, which were useful for experimenting and gaining experience with pricing policies; these concession rounds facilitated the coordination of further wind power projects through the national feed-in tariff established in 2009.

The paper finds that the Chinese Communist Party has taken strategic advantage of the fragmentation of authority in order to steer the pace of development in the wind industry. This is exemplified by the way in which the national media was unleashed to cover critical aspects of the wind industry development after 2011, and how the political careers of SOE managers and local government officials were dependent on their degree of accordance with the policies of the central government. Therefore, impulses emanate from fragmentation and help induce change, and some originate from centralisation, drawing on hierarchy and accumulated status. The legitimacy held by state-owned enterprises, the invaluable experience accumulated in established firms and the alluring prospects of political careers are all contingent on pre-existing authority. These processes are more inert and are capable of constraining, as much as aiding, change.

There are both advantages and drawbacks to the way in which the Communist Party has mobilised industry stakeholders. Some drawbacks are identified to be quality issues, the long-term performance of turbines and the danger of uniquely supporting state-owned enterprises. These drawbacks are for instance evident through the development goals set by the government, which have consistently been measured in terms of installed capacity, and not in terms of total electricity generated and delivered to the grid. Paper 1 concludes that a lack of incentive to ensure long-term electricity generation is prevalent in the whole industry chain from component suppliers to local governments approving wind farms, SOEs investing in the wind farms and grid utilities managing the wind farms. The governing practices of the Chinese government that lead to rapid growth therefore overlap with those that lead to challenges in terms of quality. This insight has implications for other new industries in China and is especially relevant for discussing the sustainability and long-term implications of China's catching up strategies.

Paper 2, 'Limits to Interactive Learning: Ensuring Quality in China's Emerging Offshore Wind Industry' picks up the thread of paper 1 and looks closely at specific practices that can

facilitate or complicate quality considerations when catching up in offshore wind technology. Assuring quality is an important endeavour, since renewable energy technologies will not be sustainable if they do not work as intended. In the paper, a distinction is made between catching up as a strategic *ambition* for latecomer firms and the *process* of catching up, which is dependent on technological learning and the development of technological capabilities within latecomer firms.

The paper first gives an overview of offshore wind industry actors in China and details technology sourcing strategies and ownership status. Entering joint ventures and licensing technology from Western firms are frequent strategies of acquiring technology in the offshore wind industry. The paper then identifies some 'usual suspects' such as time, revenue and reputation concerns that complicate processes meant to ensure product quality. Time constraints are also identified as an important reason why certification is seen mostly as a symbolic and impractical process. Therefore, in the offshore wind industry, quality conformity is unimportant in terms of actual procedures, but nonetheless affects 'face value'. Chinese firms see the European standard as a quality benchmark, and turbine manufacturers opt for 'quasi-certificates' with a foreign stamp that are satisfactory for the project developers and give them an edge on the domestic market. For the domestic Chinese industry, the actual foreign certificates are not as important as installation of the turbines. This is interpreted as a strategy of learning through experience instead of waiting for the slower certification procedure.

A central finding of the paper is that links between supplier and demander are highly unhelpful in ensuring quality in two ways: they can be too close or too shallow. As an example of the former, the relationship between the large SOE Longyuan and its subsidiary turbine manufacturer Guodian United Power was so closely tied that feedback between supplier and demander was not used to improve product performance: Guodian United Power was the untalented son that received unrelenting support. On the other end of the spectrum, shallow ties lead to 'supplier shopping' and communication blocks, leaving scant opportunity for improving and optimising components of the end product. The advantages of close and shallow ties are that local companies are chosen. However learning opportunities are missed in both cases: when ties are too close, there is a sense of duty or friendship leading to too much patience, and when ties are too shallow, supplier shopping or arrogance is characterised by a lack of patience. We may therefore conclude that better

feedback between supplier and demander could enhance learning processes and, ultimately, product quality.

By breaking down the way in which close and shallow ties may influence learning within SOEs and enterprises, more generally, in China, the paper provides a novel insight into the way in which state ownership influences the acquisition of dynamic capability. Companies may invest all the time, money and engineers they want on R&D, but consideration of supplier-manufacturer feedback may still hamper learning processes. Moreover, the paper concludes that Lundvall's (2010) theory of interactive learning and the benefits of close and sustained interaction should be nuanced: relations may indeed become so close that learning is hampered. In other words, an 'optimal' proximity must be found in order for interactive learning to occur.

The findings of paper 2 are important because if Chinese companies are not able to make products that perform according to the intended criteria, they may jeopardise a shift towards more sustainable energy industries. Malfunctioning wind turbines are easy targets for sceptics, and the momentum of renewable energy development may be reduced. These findings are not only relevant to the energy industry, but also to other industries in which communication and ties between suppliers are crucial for safety and quality.

Paper 3, 'Outside the European Box: China Developing Offshore Wind Technology' is written together with Marianne Ryghaug and addresses the role of foreign companies in China's offshore wind industry – in particular the role of European certification and advisory firms. Several countries around the world are interested in the Chinese market, and this paper provides some lessons learned from six European certification and advisory companies trying to enter China. Certification and advisory firms have an increasingly important role in innovation and development processes. As risk and uncertainty become fields to be managed, certification and advisory firms arguably gain an important role by providing evidence that a technology will function within a set of given conditions. European certification and advisory firms played a role in the development of offshore wind in Europe. Further, certification and advisory firms have proven to be important intermediaries in technology development and transfer settings. Thus, by better understanding the roles and strategies of European certification and advisory firms in the development of offshore wind energy in China, the paper shows how these European intermediaries impact innovation and technology development in China.

The paper analyses the role of intermediaries in China through three narratives: the narrative of the domestic industry that we have chosen to name 'Leave us alone!'; the narrative of the European entering companies saying 'We are necessary!'; and the narrative of the Chinese employees of the European entering companies that we call 'There is a middle way!'. The paper shows, through the narrative 'We are necessary!', that European advisory and certification companies have been relatively unsuccessful in making Chinese clients see the necessity of their services. The narrative 'There is a middle way!' suggests that some Chinese employees of these companies try to reframe the necessity of the European experience in China by referring to potential risks related to the development of offshore wind technology. However, the paper finds, in the narrative 'Leave us alone!', that the local industry evaluates the involved risks differently. The local industry wants to gain and learn from its own experiences without 'interference' from European advisory and certification agencies that the local industry thinks may impede the learning process.

The paper concludes that, although knowledge about best practice is useful, a certificate from a foreign company appears to be neither required nor desired in the domestic market. Differences in risk perception, views on the service industry and a lack of attention to local needs complicate matters for entering certification and advisory firms. The paper underlines the different evaluations of risk between China and Europe that means that certification and advisory agencies are not similarly acknowledged as legitimate actors in both regions. However, this does not rule out the possibility that certification and advisory agencies will be seen as necessary at later stages in the technology development process. The likelihood that such companies will be of foreign origin may, however, not be large. This last argument points to the role of 'intermediaries' in technology development: intermediaries may be more important within an established industry than between industries in different countries. Although international standards prove important to learn from, certification and advisory agencies are not seen as important knowledge brokers in the emerging phases of China's offshore wind industry. In this phase, it appears that maintaining control of the process is more important than managing risks defined by Europeans.

Paper 4, 'Ambition and Ambiguity: Expectations and Imaginaries Developing Offshore Wind in China' investigates the way in which future-orientation generates action in China's offshore wind industry. The success or failure of an emerging technology is contingent on peoples' claims about the future and experiences of the past (Einsiedel 2009). An emerging

technology is therefore dependent on and influenced by the expectations and visions of the surrounding society, media, government and scientific community. Expectations and visions have proven to be important in creating a 'protective space' or 'niche' for new technologies that may grow to become important technologies (e.g. Geels & Raven 2006). As China develops offshore wind energy, we may ask whether expectations are important there as well. In order to answer this question, the paper draws an analytical difference between 'industry' and the 'government' as distinct but interdependent actors. In order to study the role of the government in developing offshore wind in China, I use the concepts of a 'sociotechnical imaginary' (Jasanoff & Kim 2009) and the 'sociology of expectations' (Borup et al. 2006). A sociotechnical imaginary is an arena in which norms and active government regulation shape industry actors' policy preferences for the future. The role of the government is particularly relevant for two main reasons: first, China has an authoritarian government; second, renewable energy industries depend on government support, globally.

Using the sociology of expectations and sociotechnical imaginaries, the paper shows that the future is an important resource not only for coordinating government and industry actors, but also for calibrating and negotiating expectations about what can be achieved. On the one hand, sociotechnical imaginaries, as exemplified by government development targets, appear to spur action; on the other hand, local expectations modify the intended development targets. By describing a strategic waiting game between the government and industry actors, the analysis emphasises the fact that companies must be prepared for both change and inertia. In China, companies and politicians are future-orientated and look at what the various long-term plans have in store for them. Things can change quickly from one day to the next. Companies must therefore be prepared to be taken by surprise. I identify two characteristic components of the waiting game: first, companies delegate responsibility for their future activity to 'the government' and wait for its call; second, the government remains obscure and ambiguous, leaving industry stakeholders on their toes as to what could happen next. More importantly, however, keeping the future ambitious but the implementation ambiguous appears to be a strategy employed by the government to ensure change without detailing the road ahead. In this way, the government-induced sociotechnical imaginary is employed as an important planning tool that helps to calibrate industry development.

The paper concludes that ambitiousness about the future, but ambiguousness in implementation, is a strategy employed by the government to ensure change. With a plan-based economic history, China's visions border on loose plans, and the dynamic between imaginaries and expectations can be characterised as an efficient planning tool used by the government to calibrate plans for the future. Government targets that 'fail' to be reached are therefore not failures per se, but important indicators that are used to calibrate new targets. By making a novel nuance between expectations and imaginaries, the paper contributes to a better understanding of the dynamics of expectations and their constitutive force in China: as industry actors typically expect something to happen, the negotiation centres on *the extent to which* government imaginaries could and should be performative.

The described dynamics of future-orientation in China have several implications. For instance, the waiting game appears to be biased towards larger companies that have the means to keep large capacities idle over time and can jump the train when it starts. In China, this typically includes the large state-owned enterprises. The waiting game can therefore be used strategically to ensure domestic (state-owned) companies gain a larger market share than do other (private or foreign) companies. In effect, the waiting game can be seen as a protective mechanism that may give domestic companies a buffer zone to help them acquire the technologies of frontier companies. Another implication is that, as these concrete expectations are negotiated and manifested, the initial imaginary set by the government has a big impact in terms of the direction in which the industry develops in China. In other words, the paper establishes that the government plays an important role in constructing successful visions in China and that the concreteness of expectations in China rests on the legitimacy of previously fulfilled expectations in other industries.

Taken together, the four papers of this thesis examine different aspects of technology formation in China, including the organisations, institutions, actors and networks that are involved with innovation and learning to build a new technology. Papers 1 and 2 take a more institutional focus, as the ideas behind these two papers were formulated early on in my PhD work. Paper 1 is based on my master's thesis, which was written using the technological innovation systems approach (TIS), and my early PhD work was influenced by this line of thought. Papers 3 and 4 are more in line with thoughts that are prevalent in science and technology studies (STS) research, as this line of thinking became stronger during the course of my PhD. Paper 3 looks at specific practices of interaction from abroad

and paper 4 discusses the dynamics between the government, the industry and the influence of future-orientation in China. In order to see how the theoretical approaches of the four papers are interrelated and can highlight different aspects of innovation, the rest of this overview and tie-up essay examines conceptualisations of technological learning in 'latecomer' countries such as China, and perspectives of innovation in general. These perspectives on innovation are represented by institutional approaches, such as the innovation systems literature, and some perspectives within STS, here broadly taken to include sustainability transitions studies and actor-network theory, a perspective of innovation that is more action-oriented. These approaches may help us comprehend how innovation can be conceptualised and understood in China. Do we need an altogether new way of thinking about innovation in China, or do conceptualisations that have been developed to explain innovation in European or other Asian countries suffice? Before I go on to discuss these questions, I shall elaborate on China's current situation in terms of energy governance and the way in which innovation has been understood in China. Although the governance and politics of China cannot be adequately addressed here, two important topics will be covered: First, I will review some of the literature on energy governance in China and attempt to highlight the complexity of the matter; second, I will elaborate on the literature on innovation in China and the quest for so-called 'indigenous innovation'.

Chinese energy governance and indigenous innovation

China's story of economic catch-up and transition towards a kind of market economy starts in the reform period initiated under Deng Xiaoping in 1978 (Saich 2011; Naughton 2007). The transition began gradually during the 1980s, and was stepped up during the 1990s and especially after Deng's infamous 'Southern Tour' in 1992, during which he affirmed that the continued legitimacy for the Chinese Communist Party was dependent on economic growth (Saich 2011). Deng made this clear by stating that reform should not 'proceed slowly like a woman with bound feet' but should rather continue swiftly and 'blaze new trails boldly' (cited in Saich 2011, p.86). Decentralisation and privatisation were important ingredients in the reform process (Green & Liu 2005; Naughton 2007). Indeed, the increased authority and independence allocated to local and provincial governments under Deng Xiaoping is claimed to have been essential to achieving the high economic

performance and ensuring the legitimacy of the Communist Party (Zheng 2010). Moreover, the private sector has grown to become central to innovation activities and, in 2005, the private sector reportedly accounted for more than two-thirds of China's gross domestic product and employment (Liu 2009; Saich 2011).

Another important ingredient of the rapid growth was the gradual opening of new special economic zones that functioned as pioneering examples of the way in which new policies functioned in practice, as well as important political symbols of change (Heilmann 2008b; Naughton 2007). The most famous example is the Shenzhen special economic zone that opened in 1979, and, as of 2007, there were more than 250 experimental zones with special economic legislation (Heilmann 2008). It has increasingly become acknowledged that governance in China is not only a result of planning and control, but is also a complex system in which uncertainty is embraced as a resource for change (Heilmann 2009; Heilmann & Perry 2011). China's history with heavy government involvement and control under socialist planning was not as large an obstacle to regime change as was expected by spectators (Naughton 2010b; Naughton 2007). Instead of removing government institutions completely, as can be said to have happened in the Soviet transformation, China made use of government bodies that were seen to be 'reasonably well functioning organizations possess[ing] pools of valuable organizational and human capital' (Naughton 2010b). Naughton explains that, along with this re-purposing of Chinese institutions went 'incentivization' of government, implying that government officials received bonuses or promotions depending on how well they fulfilled certain criteria (most of which were linked to economic growth) (ibid.).

Moving more into the direction of China's energy governance, it is fairly established that the energy sector has been and still is characterised by 'fragmented authoritarianism' (Lieberthal & Oksenberg 1988; Andrews-Speed 2012; Kong 2009). This fragmentation of authority can lead to both inertia and change. Therefore, the very apex of the Communist Party, the standing committee (currently consisting of the seven highest-ranked people in China), is the most important organ that can create consensus and implement decisions (Kong 2009; Naughton 2010b; Andrews-Speed 2012; Lieberthal & Lampton 1992). Apart from the apex, however, there are internal power struggles between ministries, local and provincial governments, state-owned enterprises and even private entrepreneurs that were

officially welcomed into the CCP in 2001 (Kennedy 2005; Saich 2011). The consequences of this fragmentation are, as Andrews-Speed (2012, p.124) puts it, that

> multiple centres of power and influence exist, and China's governance of economic and industrial policy lacks the key unified sense of purpose and unified governance structure, which can be found in typical "developmental states" such as Japan, South Korea and Taiwan.

In other words, these internal power struggles cause the decision-making process to drag out in an arduous process of bargaining, persuasion and arbitration, as consensus is needed to move forward (Saich 2011; Zheng 2010). An important arena in which consensus between policymakers should be gained is policy experimentation, wherein the success of a policy is attributed to the central government, whilst responsibility for unsuccessful policy experiments is confined to local government (Heilmann 2008a; Heilmann 2008b; Naughton 2010b). In this way, successful experiments can be scaled up without much internal disagreement, whilst failed experiments do not carry large consequences for the central policymakers who suggest them (ibid.). China's decentralised structure therefore allows for experiments in selected areas, and successful experiments can then more easily be applied across the country (Andrews-Speed 2012).

State-owned enterprises (SOEs) have gained authority with the increasing decentralisation, deregulation and reform, and are therefore another source of China's 'fragmented authoritarianism' (Zheng 2010; Andrews-Speed 2012). Especially in the energy sector, SOEs play an important role in policymaking and retain considerable influence in energy decision-making processes (ibid.). One prime example is what is today known as State Grid (or the State Grid Corporation of China). In 1998, the Ministry for Electrical Power was abolished and replaced by the State Power Corporation, which, in 2002, was further unbundled into two grid companies, State Grid and Southern Grid, and five power generation companies, Huaneng, Datang, Huadian, Guodian and China Power Investment Corporation (Andrews-Speed 2012; Yi-chong 2012). Although State Grid has been fostered by and has had its 'umbilical cord' attached to the government, it has 'developed a life of its own' and ranked seventh in the Global Fortune 500 in 2011 (Yi-chong 2012, p.129).

State Grid is one of the key strategic centrally administered SOEs, and is directly managed by the State-Owned Assets Supervision and Administration Commission (SASAC). As of 2015, SASAC administered 112 SOEs (commonly referred to as 'central SOEs'), many of which concentrated on monopoly industries such as oil and gas, electricity or

telecommunication (Zheng 2010; SASAC 2015). State Grid has nevertheless been described as a 'Frankenstein's monster' with growing political influence and an increasing amount of resources at its disposal, 'eventually terrorising its own creator' (Yi-chong 2012, p.147). In other words, the company has become so large that an increasing amount of resources, both sticks and carrots, are needed for the government to manage it properly. The situation is likely to be similar in other central and local SOEs in China (Zheng 2010). 'State-owned' does not therefore equate to 'state-controlled'. Instead, these powerful enterprises are relatively autonomous actors, and sometimes advance corporate ahead of national interests (Downs 2008b). As Downs (2008a, p.137) puts it: 'China's leadership faces some of its greatest new challenges in the energy sector partly because the projects pursued by the energy SOEs tend to shape the country's energy policies rather than vice versa'.

At the World Economic Forum in Davos in January 2015, China's premier, Li Keqiang, pointed out that the 'new normal' for China's economic growth is 'shifting from high speed to medium-to-high speed, and development needs to move from low-to-medium level to medium-to-high level' (weforum.org 2015). Over the past three decades, the two most important factors in China's rapid economic growth have been increased investment from both domestic and foreign sources, and external demand (Wu 2006). Foreign direct investment has, since the beginning of the 1980s, been an important method of attracting technology to China and increasing exports (Long 2005; Naughton 2007). It is believed that foreign investment may contribute technologically in three ways: filling technological gaps, introducing advanced technology and improving existing technology (Long 2005). However, since foreign companies own the patents, copyrights and trademarks, they also receive the most profit from the technology (Kennedy 2010). In 2009, almost 56 per cent of China's exports were produced in foreign invested companies, and in high-tech exports the share was as high as 85 per cent in 2008 (ibid.). One challenge for Chinese companies has been to build local competencies whilst competing with larger and more advanced foreign companies. The Chinese government surely expected technology to spill over so as to establish domestic companies, as occurred in South Korea (Kim 1997). However, the spillover in the high-technology sector has been much lower than expected (Moran 2011; Xiao et al. 2013), hence Li Keqiang's comment on moving from low to high levels of development. China no longer wants to be the world's manufacturing floor, but wants to contribute global innovation; in short, China wants to shift the message from 'made in China' to 'designed in China' (Cao et al. 2006). How can this be achieved?

There is a large and ongoing debate on innovation and the role of government in China. As Figure 3 illustrates, the debate can roughly be grouped into, on the one hand, those who do not believe that innovation is occurring in China, and that this is due to a cultural or systemic component or to government involvement. On the other hand, there are those who believe that innovation is happening, but largely in private firms (Nee & Opper 2012), or because the government can function as a 'state entrepreneur' that facilitates innovation (Shi et al. 2014; Sun 2015).

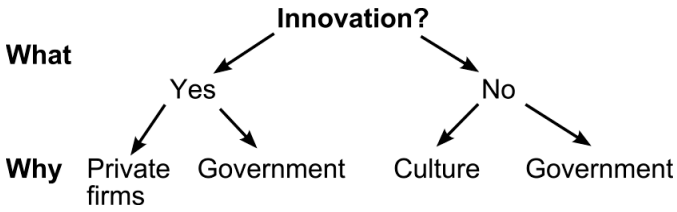

Figure 3: Views on innovation in China

Several of these stances can also be combined (Yang et al. 2012), for instance by saying that a certain type of innovation is happening in private firms, but that government control and interference is stifling another type of innovation. This was an argument made by Breznitz and Murphree (2011), who looked at China's telecommunication companies and found that government interference hindered companies from novel-product innovation. This happens, they claim, since:

> top managers are very much aware that if all goes well and they do not make any grave mistakes, they will likely be promoted and transferred to one of their rivals within a couple of years, they have little incentive for extensive investment in novel-technology, which, although it might give their current company an edge or even propel it to market dominance, carries high personal risk. (Breznitz & Murphree 2011, p.58)

Breznitz and Murphree (2011) assert that growth and 'manufacturing-innovation' in China have come about largely *because* of central-local fragmentation and not as a result of central government efforts. 'Novel product' innovations have largely failed to materialise, they argue, because the Chinese system gives preference to short-term and tangible profit. Agreeing that state support has not been central to innovation in China, Nahm and Steinfeld (2014, p.288) argue that China has become a 'scale up nation', where firms have developed 'unique capabilities surrounding technology commercialization and manufacturing-related innovation'. A similar argument is sustained by Wan et al. (2015), who claim that China is a

particularly fertile environment for *disruptive* innovations, such as 'cost innovation, application innovation, and business model innovation'. To summarise, much recent literature claims that what is happening in China is not novel product innovation, but rather disruptive and manufacturing innovation, and that the government has not played an important role in ensuring that type of innovation.

This view is somewhat contrasted by scholars who believe that innovation is happening in China (Rein 2014), and that an important source of innovation is state coordination and strategic governance (Heilmann 2010; Steinfeld 2010). Steinfeld (2010, p.164), for instance, claims that 'whether they are multinational or indigenous firms doing the work, it is in the China market that numerous new-to-the-world energy technologies are being developed and deployed for the first time'. According to Steinfeld, this is particularly true for nuclear and thermal electric power generation technologies. Moreover, analysts of the 'entrepreneurial state' hold that the courage, foresightedness and stability of the government have been crucial for paving the way for new technological developments, such as renewable energy technologies (Mazzucato 2013). Sun (2015) adapts this view to the Chinese government and finds that alertness to opportunities, resource exploration and consolidation and strategic learning are key components of China's entrepreneurial state. Using high-speed trains as a case in point, Sun claims that these three components have been crucial to building new innovative technologies in China.

On the 'no' side, there are strong opinions regarding the influence of culture on innovation performance in China. For instance, after the death of Steve Jobs in 2011, a discussion surged in China regarding 'Why can China not produce its own Steve Jobs?' (e.g. chinadaily.com.cn 2011; Mourdoukoutas 2011). Experts from China and abroad provided explanations ranging from cultural to systemic issues. For instance, one observer wrote that 'China's traditional Confucianism cannot integrate with the Western Schumpeter corporate spirit, so throughout Chinese history, we rarely see respect for innovators and businessmen' (chinadaily.com.cn 2011). On a more institutional level, Gu et al. (2009, p.385), in an overview article on innovation in China, state that:

> Chinese people believe in the positive role of science and technology while there is a weakness in social capital—values, norms and trust that are shared by the social community. Weak social capital is reflected in the low level of willingness by either academia or business enterprises to interact, cooperate and engage in knowledge

> sharing with individuals and organizations outside their family circles or immediate 'neighbors'.

Social capital, as Gu et al. (2009) see it, is important in order for firms to learn and necessary for innovation and new ideas to occur. Furthermore, Serger (2009, p.64) claims that the reason for this low willingness to share knowledge with outsiders in China is that there is a low level of trust. Corruption and intellectual property rights (IPR) infringements are taken as proxies of the level of trust, with high levels representing low trust (OECD 2008). Another scholar, Baark (2007, p.354), asserts in a study of knowledge and innovation institutions in China that:

> the predicament of innovators [in China] today may still be difficult, swimming as they do in a sea of acidic attitudes towards the new and untried, with precious little effective support from peers, officials, or the population at large.

This quote alludes to China's education system, which, according to Baark, still appears to be too heavily influenced by legacies of reproducing and refining the knowledge of the great masters of the past, encouraging 'imitation more than invention' (ibid., p.354).

In general, from the above discussion we can conclude that the answer to whether or not innovation is happening in China depends strongly on the definition of innovation employed. There are, therefore, scholars who believe that a particularly Chinese view of innovation must be interpreted through its own logic, and not through the same lens used to view Western innovation (Vinig & Bossink 2015). For this reason, Vinig and Bossink (2015, p. 621) propose that 'to better understand Chinese indigenous innovation, a new paradigm of Chinese innovation should be developed.' I do not have the ambition to develop such a new paradigm, but I believe that exploring innovation in the context of China may reveal some new insights. Regardless of how innovation is viewed, the Chinese Communist Party firmly believes that innovation is happening in China, and that China will become a leading innovation nation. This is manifested in China's 'indigenous innovation' programme, expressed in the 15-year 'Medium to Long-Term Plan for the Development of Science and Technology', issued in 2006.

The plan states that China shall transform into an 'innovation-orientated nation' by 2020, and implies how China will deal with issues such as technological dependency and domestic innovation, environmental concerns and resource utilisation, as well as human resources and education (Cao et al. 2009; Cao et al. 2006). The plan has a stated goal of increasing the

national expenditure on reseach and development from a base of 1.34 per cent of gross domestic product in 2005 to 2.5 per cent in 2020, and to reduce the dependence on imported technology to no more than 30 per cent (ibid.). Another aspect of the Chinese 'indigenous innovation' programme is not only related to technological independency, but also to developing international standards to enhance national power and international influence (Kennedy et al. 2008; Ernst 2011). Thus far, however, it appears that China's success in developing domestic standards has been limited (Kennedy et al. 2008; Fomin et al. 2011; Gao & Liu 2012). Standards are important for economic performance, since the 'owners' of a standard can shape the direction of technology development, thus giving long-term advantages to early movers (Gao & Liu 2012; Fomin et al. 2011). As Suttmeier and Yao (2004, p.17) point out, 'the technological winner is now the one who manages to control de facto market standards while at the same time protecting intellectual property rights'.

During the Great Leap Forward at the end of the 1950s, the Communist Party slogan was to 'overtake Britain and catch up with the US' (Hu 2013; Christensen 2013). It is possible to claim, therefore, that catching up with 'frontier' countries has been an important strategic achievement of China's development since the Communist Party came to power in 1949. However, just as it was a challenge for Japan and Korea before (Amsden 1989), it appears to have been a challenge for China to develop independent, 'indigenous' technological capabilities whilst, at the same time, wanting to learn from foreign countries. So what does it mean to catch up and how is catching up related to technology and innovation? What are the best strategies for developing standards and moving up the value chain?

In order to get a better understanding of the way in which technological learning may occur and how innovation in a latecomer country context has been conceptualised before, I will start by exploring what economists and economic historians have found in their research on the technological catch-up and technology transfer of now-developed countries. In the next section I outline this more traditional way of thinking and identify some of its weaknesses.

The traditional approach: Technological diffusion, transfer and catch-up

Technological catch-up can be seen as a process in one firm or country of reaching a level of technological sophistication that exists in another, 'frontier' firm, country or group of countries. Through a long-term historical perspective, technological catch-up can be

understood to have been going on since humans started farming, wherein one civilisation became more advanced than another, and this advancement moved as a pendulum between east and west on the Eurasian continent (Goody 1996). Technological catch-up is often measured in terms of the increased productivity and income of a country (Abramowitz 1986). With this measure, a division is made between countries that are technologically advanced and countries that are technologically 'backward'. The goal for these 'backward' countries is to increase productivity and achieve a higher gross domestic product. Stories of technological catch-up typically start with the industrial revolution originating in the UK in the second half of the 18th century, when surrounding countries discovered the advantages of the UK's technological advances (Bruland & Mowery 2005). The study of technological catch-up has traditionally been the domain of economists and historians such as List, Veblen and Gerschenkron, who all studied the way in which European countries such as Germany and France caught up with England (Fagerberg & Godinho 2005; Lundvall 2011).

Gerschenkron and Veblen held contrasting views on the complexities encountered by catching-up countries. Veblen formulated a hypothesis of the 'latecomer advantages' of catching-up economies, meaning that newcomers might readily adopt the most advanced technologies whilst early starters would be stuck with older or obsolete technology (Ozawa 2004). Since 'machine technologies' were relatively easy to transmit across borders, Veblen argued, it was only a question of time before other countries would make use of the new technology (Fagerberg & Godinho 2005). This was contrasted to times in which technologies were less physical and knowledge was embodied in humans, who transmitted it between each other. Gerschenkron (1962), on the other hand, argued that catching up was more difficult and involved large-scale institutional change. Based on historical evidence, he claimed that when a backward country engaged in industrialisation, the backward country showed 'considerable differences as compared with the more advanced countries' (ibid., p.7). These differences were observed not only with regard to the speed of development, but also the 'productive and organizational structures' and 'institutional instruments' (ibid., p.7). As an example, Gerschenkron referred to the role of the German banks in Germany's catching-up process. In other words, Gerschenkron recognised that catching up involved not only imitation of technological artefacts, but also institutional change and new opportunities for innovation.

Abramowitz (1986) pointed out that there is nothing self-evident about catching up, and that several contingent conditions may influence a catching-up process. He stressed two main conditions: the 'social capabilities' of a latecomer country and the 'congruity of technology and resources'. With social capabilities, Abramowitz referred to 'tenacious societal characteristics' that may account for a substantial portion of 'a country's past failure to achieve as high a level of productivity as economically more advanced countries' (ibid., p.387). He measured these by a country's average years of education and its political, commercial, industrial and financial institutions. The 'congruity of technology' argument was explored by questioning why the US was able to stay so far ahead without other countries catching up faster. Abramowitz found that the main reason, apart from the level of social capabilities, was that the US had a large advantage in terms of available resources and a large domestic market that allowed industrial plants to be scaled up. A catching-up country may, therefore, even with a similar level of social capability, lack the necessary resources or domestic market to succeed. In other words, there is no recipe for successful catch-up, and each country has to plot its own distinctive path (Hobday 2003).

Nevertheless, we may draw some lessons from other 'late industrializers', as Amsden (1989) calls them, such as Japan and Korea. Countries that have caught up with frontier countries have often protected their industry and cunningly learned to master frontier technology. Chang (2007) stresses the importance of regulating foreign investments so as to protect and build a national industry. Chang bases his argument on a historical review of now-developed countries, such as Norway, Finland and Japan. Until the 1980s, for instance, Japan 'was virtually closed to foreign investment' (ibid, p.16). Interestingly, Japan also emerged as a global technical power in the 1980s concurrent with a more open policy for foreign investment. Thus, opening the economy at the right time appears to be one important aspect of catch-up. Other commonalities of now-developed countries include their considerable cross-border flow of people, active government support for domestic companies and weak regulation of intellectual property rights (IPR) (Nelson 2004a).

IPRs play an important role for the firm that owns the technology, as property rights hinder others from using the technology without paying for it. It has been claimed that strong intellectual property right protection incentivises investment in research and development (Xue & Liang 2010), which is often taken as an indicator of the intensity of a firm's learning effort and, hence, success (Cohen & Levinthal 1990). Originally, developing

countries were strongly opposed to an international intellectual property rights system because they argued that it only benefitted states that were already technologically strong (Rosendal 2001). In other words, those that owned the knowledge had the upper hand. Since China became a member of the WTO in 2001 (Suttmeier & Yao 2004), it has had to enforce stronger patent legislation, in line with the trade-related aspects of intellectual property rights (Naughton 2007). Since China has profited from foreign investment, the challenge has been two-fold: meeting the demand for strong property right protection of multinational companies and satisfying domestic companies, which 'favored an IPR regime conducive to technology transfer and knowledge diffusion' (Xue & Liang 2009, p.318).

Technological catch-up and technology transfer are closely connected. Abramowitz (1986, p.401) maintains that the flow of knowledge from leader to follower is 'the very essence of the catch-up hypothesis'. The conventional wisdom is that, since the economic growth of any country is dependent on its successful usage of a transnational stock of knowledge (Kuznets 1966), technology must somehow be transferred to the catching-up country (Teece 1977). A common understanding of technology transfer draws on the model of diffusion: the time it takes for others to adopt the innovation of one firm (Mansfield 1961). On a firm level, technology transfer is seen largely as an imitation of someone else's invention. This does not, however, imply that the imitator is less innovative. As pointed out by Kline and Rosenberg (1986), many important innovations happen as a product or a process diffuses. This means, therefore, that imitation and diffusion are important and necessary features of innovation, itself, necessary in order to create new knowledge (Hall 2005).

Two influential approaches used to explain technology transfer are the so-called 'dependency school' and the 'appropriate technology' movement. The dependency school, with its main proponents being authors such as Prebisch and Gunder Frank, claims that developing countries are 'technologically dependent on the interests and decisions of foreign investors from the advanced world' (Perez 2013, p.92). The appropriate technology movement emphasises that developing countries have different needs, so the technology transferred should be better adapted to their endowments – typically, this implies more labour-intense technologies (ibid.). Another influential account of technology transfer is the 'product cycle' theory set out by Vernon (1966). The product cycle theory states that high-income countries are the first to spot opportunities for new products, and that these products are produced within those countries for reasons pertaining to close geographic and material

linkages. In other words, advanced industrial countries are the first to innovate, and less advanced countries start producing that product only at a later and more standardised stage of the product cycle. Common to all of these approaches is the understanding that technology comes from more advanced countries and is distributed in some way and at some point to less advanced countries.

In developing countries, technology transfer is typically considered to occur through foreign direct investment (FDI), wherein the 'donor' firm fully owns and controls the facility; joint ventures, wherein local firms also own a share of the production; or technology licensing through a contract fee (Baranson 1970). Other technology transfer mechanisms are considered more informal, such as technical assistance or reverse engineering of products that have been imported (Kim 1997). It is generally accepted that the transfer environment in the 'recipient' country and the absorptive capacities of recipient firms are important determinants of the success of technology transfer (Baranson 1970; Cohen & Levinthal 1990). Some scholars refer to technology 'spillover' when addressing technology transfer, meaning that local firms may improve as international companies enter (Kokko 1994; Blomström & Sjöholm 1999). If technology transfer does not lead to spillover, it may, on the other hand, lead to 'crowding out effects', which suffocate the local industry rather than support it (Barry et al. 2005). Although the jury is still out on the effects of foreign investment, some studies have found that donor firms will transfer less advanced technology if the host country has policies that involve ownership limits or technology sharing mandates relating to foreign investors (Moran et al. 2005). This was the case in China, where Volkswagen, in a joint venture with Shanghai Automotive Company from 1985 onwards, continued to produce an outdated and unimproved automobile model due to a lack of domestic competition (Long 2005). Ironically, the technology sharing policy that had been implemented in order to allow local firms to learn had a backwards effect: without domestic competition, Volkswagen dominated the market with its old technology and had no incentives to modernise (ibid.).

Technological catch-up can be seen as a rather remarkable feat, given that knowledge is needed to gain new knowledge, skills beget skills and capital fosters more capital (Perez & Soete 1988). For an outsider firm or country, it appears difficult to enter such a complex and self-subsisting system. However, it is not only the knowledge and experiences of the 'advanced' countries that are important in order to catch up. History has shown that, as

countries catch up, they tend to generate innovation and unseen opportunities (Fagerberg & Godinho 2005). Such innovation and unseen opportunities occurred, for instance, when both Germany and the US started catching up with the UK during the course of the 19th century (ibid.). Perez and Soete (1988) argue that technological catch-up becomes a possibility mainly through 'windows of opportunity' that arise because a new setting creates new opportunities. One such setting is the information and communication technology 'revolution' that started in the 1970s (Perez 2010; Perez 2013). Technological catch-up, understood this way, is distinguished from approaches that see development as a 'race along a fixed track, where catching up will be merely a question of relative speed' (Perez & Soete 1988, p. 460). Instead, catching up is a process wherein a country seeks to reach a certain level of development, and, in that process, may innovate and create new avenues for growth. Consequently, catch-up in this understanding can be seen more as 'creating new' rather than 'imitating old'. This means, then, that in each case of a historical catch-up, whether it was Germany, the US, Japan or Korea, something new was added. Simplified put, a retrospective look at catch-up may help to gain a better understanding of how a particular country learned, but this knowledge might partly be unusable for another catching up country as the window of opportunity has already been covered.

To summarise, the technology transfer and diffusion literature typically places technology at the centre, as an artefact that should be moved across borders. This transfer of technology is expected to help less-advanced countries. We may ask, however, if 'donor' and 'recipient' are appropriate denominations, given that both donor and recipient have their own reasons for engaging with technology transfer. The catch-up literature looks at the situation within the country that wishes to become more advanced, and the strategies it takes to acquire the technology and economic development of frontier countries. Technology transfer and catch-up can be illustrated as numbers 1 and 2, respectively in Figure 4.

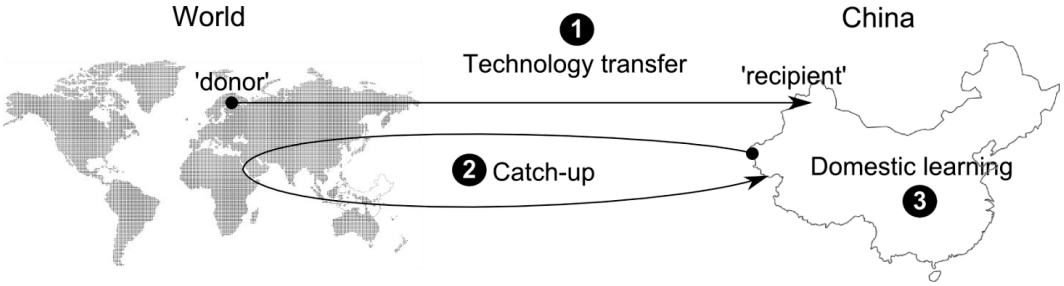

Figure 4: Technology transfer, catch-up and domestic learning

However, catch-up strategies are not only about imitating the technologies and procedures of forerunners, but also about creating new opportunities. As Amsden (1989, p.329) concludes in her seminal study on technological catch-up in South Korea: 'Japanese and now Korean economic history (…) teaches that we may expect not merely imitation and copying from learners—the longstanding stereotype. We may also expect creativity, because learning itself turns out to be a highly creative process.' Consequently, we need to look more closely at domestic learning, as number 3 in Figure 4 indicates.

Although foreign direct investment can lead to economic growth, catching-up countries typically want to own and master the technology that is transferred. This is one reason why several innovation scholars refer to learning as the most important source of technological catch-up (Amsden 1989; Lundvall 2007; Lundvall 2011). In other words, successful catch-up boils down to successful learning and innovation. In recognition of this, we can make the following distinction between catch-up as an *ambition* and the catching-up *process*. Catch-up as an ambition is simply the knowledge that another 'advanced' industry exists and the ambition to one day compete on equal terms with that industry. The catching-up process, however, is characterised by learning and stimulating an environment that is beneficial for innovation.

In other words, theories of technology diffusion, transfer and catch-up tend to give too much weight to explanatory factors that come from the outside and should be readily adopted and accepted in the catching-up country. Technology is seen as an exogenous and isolated factor that remains similar across geographical space. This is not satisfactory because it fails to give due attention to the domestic learning processes that are accompanied with the introduction of something new. Hence, we may ask: How can the domestic environment of a catching-up country become innovative? This issue is studied closer by evolutionary economists who emphasise the importance of building domestic capabilities that accommodate for new technologies through supporting institutions, organisations and networks—or innovation systems as they are called. Next, we take a closer look at the innovation systems literature in order to see how this line of thought conceptualises innovation and learning, and what it considers significant constituents of industry development. Thus, this literature may be helpful in distinguishing some indications of how we can understand and conceptualise China's offshore wind industry development.

The alternative from evolutionary economics: Innovation systems

The innovation systems literature developed in the 1980s as a response to mainstream economic theory, which treats innovations as extraordinary, exogenous events (Lundvall 2010). Innovation systems analysts argue that innovation should not be regarded as a single, isolated event (Kline & Rosenberg 1986). Rather, innovation is ubiquitous, continuous and cumulative – a process whereby interactive learning and collective entrepreneurship are crucial components (Lundvall 1988). Innovation systems theorists take as a starting point the idea that technology develops in a web of interactions between actors, networks and institutions. Innovation is seen to result from a broad spectrum of factors, and not only through market forces or research and development (R&D). From the outset, the concept of *national* innovation systems was thought to be a useful way of thinking about the manners in which less developed countries try to catch up (Liu 2009; Lundvall 2011). This idea was mainly based on the work of one of the founders of the approach, Christopher Freeman, and his attempt to explain Japan's economic success (ibid.). Apart from Freeman, other early developers of national innovation systems were Lundvall and Nelson (Lundvall 2010), and the concept was rooted in the work of the 19th century economist Friedrich List – particularly his research on 'national systems of production' (Carlsson 2006). Innovation systems scholars also take as a starting point the work of Schumpeter, who emphasised the importance of innovation for economic growth and defined innovation as a new combination of already existing knowledge (Lundvall 2010).

National systems of innovation have been defined in different ways. Lundvall (1988) emphasises the interactive aspects of national innovation systems, seeing user-producer relations as important to the innovation performance of a country. These user-producer relationships, Lundvall argues, are crucial for successful innovation and are determined largely by a country's organisational and institutional set-up. A common feature in most definitions of national innovation systems is the role given to a country's institutions, and the way in which these institutions interact in order to facilitate innovation. Reviewing many of the definitions given, Lundvall et al. (2009, p.6) propose the following definition:

> The national innovation system is an open, evolving and complex system that encompasses relationships within and between organizations, institutions and socio-economic structures which determine the rate and direction of innovation and

> competence-building emanating from processes of science-based and experience-based learning.

Apart from the reference to the 'national', this definition does not say anything about the borders of a country, but rather emphasises structures – relationships, institutions and socioeconomic – within an unspecified area. Also, the definition includes aspects of learning and competence-building, pointing out that these are crucial for innovation performance in any given area.

Given the importance of the institutional set-up, it is appropriate to look closely at what is meant by institutions. Since economic systems are filled with uncertainty, institutions 'provide agents and collectives with guide-posts for action' (Lundvall 2010, p.10). These institutions may be 'routines, guiding everyday actions in production, distribution and consumption, but they may also be guide-posts for change' (ibid., p.10). Institutions typically evolve over time, and regulate – either directly or indirectly – the way in which actors relate to each other (Johnson 2010). Important features of institutions include their ability to coordinate the use of knowledge, mediate conflicts and provide incentive systems for involved actors (ibid.). Institutions create social stability – stability that produces inertia but also provides the necessary platform for changes to occur (ibid.). The successful introduction of new technology is determined by the way in which institutions change. This means that the actors in a system compete not only for customers, but also for influence on the institutions in the system (Jacobsson 2011). Lundvall (2010) also draws a distinction between broad and narrow definitions of national innovation systems. The broad definition includes:

> all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring – the production system, the marketing system and the system of finance present themselves as sub-systems in which learning takes place. (Ibid., p.13)

The narrow definition, on the other hand, includes 'organisations and institutions involved in searching and exploring – such as R&D-departments, technological institutes and universities' (ibid., p.13).

Edquist (2005, p.188) explains that institutions have been treated relatively incoherently within the innovation systems literature, which sometimes refers to the 'rules of the game' and sometimes to the 'players in the game'. For example, Lundvall traditionally referred to institutions as rules, whilst Nelson and Rosenberg treat them as the different kinds of

organisations included in an innovation systems (ibid., p.186). Edquist (2005) therefore distinguishes the two main components of innovation systems into organisations, such as firms, universities and public agencies, and institutions, such as laws, rules and norms. More generally, we can say that the organisations that constitute an innovation system are the firms, the public sector, the financial sector and research and development organisations (Lundvall 2010). One of the most important aspects of an innovation system is the internal organisation of firms, and interfirm relationships (ibid.). The firm is therefore often at the centre of innovation systems analyses. The public sector is important both as a *user* of innovation – for instance in creating new markets through public procurement policies – and a *producer* of innovation, in establishing arenas for research and development and human resources – for instance, through universities (Gregersen 2010). Banks and financial institutions are crucial for paving the way for new initiatives and supporting innovative activities. These financial institutions may differ considerably between countries and may have great effects on innovation performance (Christensen 2010). Lastly, research and development may occur both within firms and private research institutes and within research universities, depending on the practices of each country (Edquist 2005).

Learning is given an important role in innovation systems conceptualisations, and, as established in the previous section, learning is important in the catching-up process of latecomer firms. Learning has been studied by a number of scholars from a range of disciplines, and there is little agreement over what it is and how it occurs (Dodgson 1993). Within the innovation systems literature, learning is essentially understood to pertain to how and who couples knowledge. Knowledge is taken to be a vital resource for innovation, whilst learning is often understood as an essential activity accompanied by innovation (Lundvall 2010). Johnson (2010) distinguishes four types of learning according to the level of human interaction involved, from the least to the most interaction: 1) imprinting, taken to be isolated and immediate experiences in the memory of individuals; 2) learning by repetition, which does not necessarily involve an understanding of what is done; 3) learning by feedback, meaning that others will comment upon and say something about the first action and try again based on the response; and 4), systematic and organised searching for knowledge, typically conducted by universities or corporate research and development departments. This classification is only one way of distinguishing learning modes.

Others have distinguished between higher- and lower-level learning, generative and adaptive learning, strategic and tactical learning and learning in terms of single or double loops (Dodgson 1993). A rather popular distinction in learning is connected to two types of knowledge, as set out by Polyani, namely tacit and codified or explicit knowledge (Howells & Roberts 2000). Codified knowledge can be defined as:

> knowledge which can be written down in the form of a document, manual, blueprint or operating procedure. In contrast, tacit knowledge is disembodied know-how, which is acquired via the informal take-up of learned behaviour and procedures. (Ibid., p.20)

Polyani distinguished this from tacit knowledge because he wanted to emphasise that we can 'know more than we can tell' (Sørensen & Levold 1992, p.20). Although I will continue to refer to these two types of knowledge, the dichotomy is a simplification, since there will always be elements of tacit knowledge. Therefore, as also pointed out by Polyani, a wholly codified knowledge is impossible (Howells & Roberts 2000).

In terms of the previous discussion on technology transfer, we can note that Veblen assumed that technology transfer would be easier with the advent of industrialisation precisely because technology and knowledge would become more explicit relative to pre-industrial times, when knowledge was embodied in people (Fagerberg & Godinho 2005). Indeed, the main way in which knowledge has been transmitted from generation to generation has been through apprenticeships (Gorman 2002). Gorman (2002) distinguishes between four types of knowledge, all of which can be both tacit and explicit: information (what), skills (how), judgement (when) and wisdom (why). Gorman concludes that organisations essentially struggle to transfer technologies due to the challenge of transforming knowledge from tacit to explicit, and vice-versa. This challenge is further complicated by the 'twin-problems' of embeddedness and embodiment:

> Embeddedness refers to the tacit social context which contributes to judgement, including technological frames, distributed knowledge, transactive memory and shared mental models. Embodiment refers to the tacit skills that makes human beings able to solve problems with a kinesthetic component. (Gorman 2002, p.229)

In other words, knowledge is not only tacit or embodied, but also embedded in a context that may facilitate or hamper technology transfer. For this reason, Howells and Roberts (2000) argue that knowledge systems must be seen to be broader than innovation systems;

while knowledge cannot be separated from the individual, it is also highly contingent on social relations.

Feng (2010) uses the metaphor of 'water' for knowledge, and 'looking for water' for technological learning. Mobilising a lot of people in the search for water is not enough in itself, he says. People also need to know what water they should look for (from the ground, from the air, etc.) and how to collect the water (by digging a canal or a well, collecting it from the air, etc.). Technological learning for catching-up companies can, through this metaphor, be compared to 'a community looking for water in a desert' (ibid., p.31). For the present analysis of China and learning, this implies that there must be a *base* to start from in the development of a new industry; in other words, there must be some water to look for. However, it is rather open whether or not the learning process will generate the same knowledge as the base consists of (e.g. the search for water may result in the discovery of a new way to collect water).

A division between science-based and experience-based learning has received increased attention in discussions of learning mechanisms connected with explicit and tacit knowledge (Jensen et al. 2007; Isaksen & Nilsson 2012; Lundvall 2011). Since policy has traditionally given greater attention to science, research and development as the most important contributions to innovation, Jensen et al. (2007) emphasise that both science-based *and* experience-based learning are crucial for innovation. Science-based learning is abbreviated as STI (science, technology and innovation), and refers typically to research and development and activities that generate 'know-why'. Experience-based learning is abbreviated as DUI (doing, using and interacting), and refers to more tacit and localised aspects of knowledge that generate 'know-how' and 'know-who'. The DUI learning mode balances the focus on scientific learning, and it is necessary because 'practice in most fields remains only partially understood, and much of engineering design practice involves solutions to problems that professional engineers have learned "work", without any particularly sophisticated understanding of why' (Nelson 2004b). In other words, as we turn to look at China's offshore wind industry, the most important variables that can explain success are not only the amount of research and development, but also learning processes within firms, and the ways in which actors interact, use and gain hands-on experience in order to steadily improve a product (Kamp et al. 2004).

One aspect of learning that appears to be somewhat neglected within innovation systems literature, is that not only firms can learn, but also other involved actors, such as the customers, local communities or research agencies. Garud and Karnøe (2003) introduce a different understanding of learning by using the concepts 'bricolage' and 'breakthrough' to describe contrasting learning modes in the Danish and US wind turbine industries. The (successful) Danish version is called 'bricolage', which refers to a path on which the technology and a range of actors are tied together in a process of co-evolution. This mode of learning implies that the designers, manufacturers, users, policymakers and other actors involved in the making of technology must respond to each other and new versions of the technology as it evolves. Learning and agency are distributed across the participating actors, goals are continuously reformulated and technological development proceeds in incremental steps. 'Breakthrough', on the other hand, refers to a path on which certain technological waypoints and goals are articulated more clearly. The US wind turbine industry pursued a rather unsuccessful 'linear' engineering science-based technology push-model (ibid.). Garud and Karnøe (2003) thus conclude that, in some cases, the seemingly simpler bricolage approach may possess significant advantages over the sophisticated high-tech breakthrough approach, as the latter may stifle the micro-learning processes that allow for the mutual co-shaping of emerging technological paths. In the cross-cutting analysis section of this overview and tie-up essay I will take this point into consideration when discussing how policy learning has happened in China's wind industry.

Under the innovation systems umbrella, there are several ways of defining levels of analysis, and these can roughly be grouped into two main approaches: one that 'delineates systems on the basis of technological, industrial, or sectoral characteristics' and one that emphasises geography, such as national or regional borders (Fagerberg et al. 2005, p.12). Both approaches share a systemic focus, meaning that they do not understand innovation activities in isolation. One of the pioneers of the study of technical systems, Thomas P. Hughes (1983, p.5), emphasised that the interconnected components of technical systems 'are often centrally controlled, and usually the limits of the system are established by the extent of this control'. Further, this control is practised in order to 'optimize the system's performance and to direct the system toward the achievement of goals' (ibid.). The goal of an electric production system, for instance, is to produce enough electricity for the end-user. Therefore, one may say that the different components of the system all contribute to the goal

of the system; otherwise, they are not part of the system. The overall goal of an innovation system is often taken to be 'to develop, diffuse and use innovation' (Edquist 2005 p.190).

As this thesis deals with a particular technology, offshore wind technology, one could argue that the most relevant focus within the innovation systems literature apart from the national focus is the focus on *technological* systems. Carlsson and Stankiewicz (1991) find that technological systems differ from national systems in three ways. First, the former refer to a specific 'techno-industrial area', instead of all areas of a national system. Second, technological systems are not necessarily restrained by national borders. This means, for instance, that industries that are international in nature can be included in the analysis. Third, they emphasise micro-economic aspects because the macro-perspective is weak in pinpointing exactly what contributes where. The technological innovation systems (TIS) framework (Bergek et al. 2008) maps the structural characteristics of a specific innovation system and attempts to develop concrete suggestions of 'functions', or key processes, which need to be fulfilled in order for an innovation system to operate optimally. By assessing each 'key process', it is possible to judge how and how well an innovation system works (Bergek 2002; Bergek et al. 2008; Hekkert & Negro 2009). Proponents of the TIS framework claim it is a tool that is 'effective for capturing dynamics in emerging technologies and industries' (Karltorp 2014, p.v) and particularly strong in 'identifying bottlenecks and systemic strengths and weaknesses' (Hanson et al. 2011, p.2).

Having described some of the characteristics of innovation systems, we may formulate some expectations for the emerging innovation system of China's offshore wind industry. As pointed out, institutions and organisations that accommodate both science-based and experience-based learning – both within and between firms – are central. Moreover, we may expect financial institutions to be tuned towards the support of offshore wind technology, research and development activities to be supported and engaged in, and public institutions to help create markets, for instance through public procurement. With these expectations, we can start thinking about how China's offshore wind innovation system may look.

Within the innovation systems approach, there is a prevailing conception that there are important differences between national innovation systems in developed and developing countries (Lundvall 1988; Liu 2009). However, Liu and White (2001, p.1112) look specifically at innovation systems in China, and conclude that:

> It is far from clear that evolving into an innovation system similar to that found in developed market economies is a possible or even advisable objective for China or other countries emerging from central planning regimes and Soviet-style industrial organization.

Although it is relatively clear that the Chinese government wants to achieve long-term economic growth and prosperity for more of its inhabitants, we must ask what the right type of innovation system in China is. For instance, although institutions and organisations may be present and 'strong', we may also ask who are maintaining the system and who induce change within it. How is such change achieved? One critique of innovation systems approaches may therefore be that it fails to provide tools and perspectives that highlight how institutions, organisations and learning may change, and how new ones may emerge.

Somewhat simplified, we may say that if I have been able to map all firms, banking institutions, research institutions and government agencies related to offshore wind in China, I might know a lot about how the system looks, and how one company acquired technology through R&D or other types of learning. Yet, I might have no specific idea of exactly how these came into existence, who supported them and what struggles they went through to end up there. Was it a group of five environmentally interested people who started a company or was it a large state-owned company that decided to start a new and 'green' branch? Was it a farmer that decided to try to harness the wind and got help from his neighbours to build a turbine? Or was it a high-tech, top-down initiative financed by the government? Was it perhaps a large movement of people who were tired of pollution in a Chinese city? How were these initiatives able to make a mark, and create an emerging space for action? These questions highlight movements and initiatives that arise due to for instance societal, environmental or political interventions and influences.

Since the internal dynamics of any country or industry arguably is different, it might therefore be too simple to assume that certain organisations and institutions are more important than others. Companies, market signals or government policies are different in China, and this means that the actions and strategies of involved actors can also be different. The point is not to say that bottom-up is better than top-down, that micro is better than macro, or that a social aspect is more important than a technological, and so on. The point is rather that by distinguishing a specific technological innovation project, we might neglect societal, environmental, political or other factors that are relevant. In other words, the innovation systems approach fails to adequately address how relations can be seen as both

social and technological at the same time (Bijker and Law 1992). In practical terms, this amongst other things involves examining the co-production of power, conflicts of interest, politics and technology and how this co-production shapes and impacts developments. This may be particularly important in a Chinese context, where the role of the Chinese Communist Party is so prevalent and impacts so many processes (Tyfield et al. 2015).

In the next section I introduce two science and technology studies perspectives on innovation. These perspectives may help overcoming some of the weaknesses of the innovation systems approach by critically asking how change can occur within a system, and how stability is maintained: how things, people and concepts are assembled, mobilised and circulated into what they are known as today.

Science and technology studies perspectives of innovation

As mentioned in the introduction of this overview and tie-up essay, one part of my endeavour is to gain a better understanding of how innovation in China's offshore wind industry can be understood and conceptualised. Had this not been part of my objective, the innovation systems model would probably have sufficed as an analytical tool to understand the development of China's offshore wind industry. However, as just explained, innovation systems thinking tends to see the world through fixed boxes that by and large remain the same over time. This is why it can be said to reside within a structuralist or institutionalist ontology. The basic assumption within science and technology studies (STS) is that science and technology are social activities, embedded in society like any other activities (Sismondo 2004). This means that science and knowledge are not simple truths deducted from nature, but influenced for instance by the community at large, or rhetorical work in order to convince other people (ibid.). Nevertheless, STS is not a single well defined body of work, and what approaches should be included in the term is continuously debated. According to Russel and Williams (2002, p. 61) one broad strand within STS has sought ways of 'reconciling and articulating different levels of analysis' whilst another, by contrast, has 'retained a strong sceptiscim towards the very idea [of structures] (…)'. I have here chosen to highlight two perspectives that focus on innovation, namely sustainability transition perspectives and actor-network theory (ANT). Sustainability transitions perspectives can be said to belong in the first, reconciling strand, whilst ANT has remained sceptical to the

notion of levels and structures, and can be said to have a 'flat' ontology, meaning that there are no (or only one) levels. To summarise, IS believes in institutions and structures, sustainability transitions has sought a 'middle way' and ANT is 'flat'. The ontological difference between these three perspectives allows for an interesting discussion of how innovation can be understood and conceptualised in China. I return to this discussion after having introduced the approaches, starting with sustainability transition perspectives.

Sustainability transition perspectives

The growth of new technologies and the disruption of established regimes have been studied from several angles. Sustainability transition studies focus explicitly on technological change and sustainability. The word transition is a common concept used to explain what has been happening in China since the reform period that began in 1978 (e.g. Dittmer & Liu 2006; Hussain 2002). However, unlike technological transitions-as-usual, which, by and large, are emergent, sustainability transitions are intentional and involve the coordination of several actors aiming at an agreed upon purpose (Markard et al. 2012). The single most influential concept in transition research is the 'sociotechnical regime' (ibid.), which builds heavily on Nelson and Winter's (1982) concept of technological regimes (Geels 2002). This implies that transition studies have much in common with innovation systems thinking. In general, technological regimes are taken to encompass all of the factors that influence, support and constrain the development of a technology, including production and thought processes, routines, knowledge and learning (Dosi & Nelson 1994). Conceptualisations of technological regimes are frequently referred to in descriptions of the way in which learning and the knowledge environment shape the direction in which technology develops through tacit agreements of involved agents (Malerba 2005).

When looking at energy industries insights on regimes become evident since large infrastructures are already in place, and these do not necessarily cater for intermittent renewable energy technologies (Kemp 1994). Renewal of energy technologies happens especially slowly because capital expenses are large and investments are long-term, ranging from 30 to 40 years for an average coal power station (Jørgensen & Münster 2010, p.10). Most countries' electric power systems are fuelled by fossil fuels and have developed over time, creating vested benefits for the continued use of fossil fuels. This development has been termed a 'carbon lock-in', and is considered one of the prime reasons new renewable

energy technologies face difficulty (Unruh 2000). Such concerns served as the backdrop to how thinking on sustainability transition perspectives emerged (Kemp 1994). Three central theoretical contributions within this literature are the multi-level perspective (MLP), strategic niche management and transition management. I start by outlining strategic niche management, because this type of strategy might be something the Chinese government is pursuing with China's offshore wind industry.

Strategic niche management and transitions management appear to have been inspired directly by the concern that the current technological situation is environmentally unsustainable (Kemp 1994; Kemp & Rotmans 2005). The strategic niche management framework is based on historical studies of technological regime shifts (Kemp et al. 1998). Kemp et al. (1998, p.183) found that there are two important lessons: first, 'entrepreneurs/system builders and niches play an important role in the transition process[es]', and second, there is an 'availability of niches or domains for application'. This latter point means that there needs to be a market for new technologies, so that a 'protected space' can enable the niche to develop. This was, for instance, the case with many important technologies of the 20th century that received special support through military or other state funding, such as radios, aircrafts and computers (Kemp et al. 1998; Mazzucato 2013). Kemp et al. (1998, p.186) therefore proposed the following definition:

> strategic niche management is the creation, development and controlled phase-out of protected spaces for the development and use of promising technologies by means of experimentation, with the aim of (1) learning about the desirability of the new technology and (2) enhancing the further development and the rate of application of the new technology.

The definition points out that a protected space must eventually be phased out, since the technology will either become successful and no longer need protection, or it will fail, in which case further support would not make sense. Three elements characterise successful niche emergence and growth: visions and expectations, networks and learning (Seyfang & Longhurst 2013). Visions and expectations must be shared, networks must encompass several stakeholders and learning 'should contribute not only to everyday knowledge and expertise, but also to "second-order learning" wherein people question the assumptions and constraints of mainstream systems altogether' (ibid., p.882). The role of the government as a supporter, protector and nourisher of niches is relatively implicit, as there are few other actors with the means, foresightedness and courage to take on such a role, as pointed out by

Mazzucato (2013). We can therefore expect the Chinese government to take an active role in the formation of a potential Chinese offshore wind niche.

The multi-level perspective (MLP) is inspired by strategic niche management thinking and introduces a comprehensive model of how change can occur through multiple levels. Briefly put, MLP distinguishes between three levels of the complex dynamic of technological transitions. The macro-level is named the 'landscape', and is based on the theorisation of technological trajectories 'consisting of a set of deep structural trends' (Geels 2002, p.1260). The macro-level is perceived as exogenous, and may, for instance, include globalisation, the natural environment or political and cultural attitudes. The meso-level is the 'sociotechnical regime', defined as a 'semi-coherent set of rules carried by different social groups' that orientates and coordinates relevant actors (ibid.). Examples could be the coal industrial generation of power for customers, the role of automobiles for personal transportation or the assembly line organisation of manufacturing. The micro-level consists of technological niches that provide novelty and may, at some point, disrupt an established sociotechnical regime. Examples are start-up enterprises, demonstration projects (usually heavily subsidised), or small communities of early adopters of new technologies. Change may, however, originate from any of these three levels. The main contribution of the multi-level perspective to the innovation systems literature is the introduction of a user perspective and the use of institutions to explain the 'dynamic interplay between actors and structures', and hence change from one system to another (Geels 2004, p.897). Figure 5 below shows one way to visualise the multi-level perspective.

Transition management was originally formulated as a management strategy for public decision-makers and can be said to be an action-oriented or process-oriented version of the MLP (Rotmans et al. 2001). It places itself between bottom-up approaches – such as strategic nice management – and top-down approaches that entail comprehensive planning and political steering (Kemp et al. 2007). Overarching policy steering is identified as difficult due to challenges with distributed control (actors have different levels of authority, depending on the area), dissent (actors have diverging opinions about sustainability) and political myopia (politicians tend to be short-sighted, but transitions take time) (ibid.). By combining elements of long-term planning with incrementalism, the transition management approach sets out to:

> create a societal movement through new coalitions, partnerships and networks around arenas that allow for building up continuous pressure on the political and market arena to safeguard the long-term orientation and goals of the transition process. (Loorbach & Rotmans 2010, p.239)

Transition management approaches also place significant emphasis on the role of guiding visions that can motivate and coordinate actors (Smith et al. 2005). Briefly put, the transition management approach is concerned with problems that relate to both short-term concerns and long-term imperatives, and it is explicitly pointed out that the 'government can and should assume a leading role in transition management' (Rotmans et al. 2001, p. 25). The role of government should be that of reflexive and evolutionary management, with government actors taking on multiple roles, such as facilitators, stimulators, controllers or directors, depending on the perceived stage of transition (Markard et al. 2012; Rotmans et al. 2001).

The transition management perspective can be said to be a design of what has been termed reflexive governance (Voß and Bornemann 2011). Reflexive governance means that governments understand themselves to be part of the dynamics that they govern. As pointed out by Voß and Kemp (2005, p.4) reflexive governance incorporates feedback

> by opening problem-handling processes for diverse knowledge, values and resources of influence in order to learn about appropriate problem-definitions, targets and strategies of governance for sustainable development. As such reflexive governance is about the organisation (modulation) of recursive feedback relations between distributed steering activities.

Hence, reflexive governance means to be open for learning and changing policy according to what the (new) aim is, and what proves to be effective policy-measures. Indeed, reflexive governance appears to be a way of learning so that policy can be optimised according to the sustainability criteria at hand. Therefore, experimentation and learning by doing are approaches that transition management scholars emphasise (Voß and Bornemann 2011; Voß and Kemp 2005).

As mentioned in the introduction, there are three main reasons why it is interesting to introduce the sustainability transition perspective in my analysis. These three are: 1) the way in which change is conceptualised, 2) the perspective on how the government can work through active management and niche support, and 3) it is relevant for renewable energy technologies that are considered more environmentally sustainable. Both the strategic niche management and transitions management highlight the important role of the government in

innovation and transition processes. Lately, the important role of the government as a facilitator of innovation has been emphasised by scholars such as Mazzucato (2013). In China, the government is an important actor, and sustainability transitions thinking represents an interesting model of how to think about the role of the government in transition processes. In recent years, the MLP is perhaps the perspective that has gained the most popularity and that has gone furthest in describing how sociotechnical change might occur. Nevertheless, the MLP, in line with the innovation systems approach, has been criticised for not including underlying politics and power into their sociotechnical regime concept (Geels 2014). Geels (2014) suggests that this can be solved by adding concepts from for instance political economy or by attempting to understand better how regime actors use power to resist change.

This first suggestion is something ANT would be sceptical towards: can we really add concepts on top of concepts and hope that this might bring us any closer to reality (Latour 2005)? As we continue to towards the more empirical part of this overview and tie-up essay, we may ask ourselves: if we observe the creation of an offshore wind niche, how does it occur, and who are the proponents of it? Can China's emerging renewable energy industries be considered 'niches' that enter and destabilise an existing regime, or do they rather originate from within the regime, itself? What is the role of the Chinese government in supporting such a niche? Who are the regime actors, and how do they use their power to resist or promote change? These questions will be explored in the section called 'Experiments, niches and learning' later. Now, I elaborate more on the 'flat' ontology of actor-network theory.

Actor-network theory

> Innovation is the art of interesting an increasing number of allies who will make you stronger and stronger.
>
> Akrich et al. (2002a, p.205)

Actor-network theory (ANT) takes, as a point of departure that technology does not develop in a vacuum, nor is one single person responsible for inventing and developing it. By closely examining and 'opening up' the innovation process, ANT analyses the way in which technologies are compiled to become innovations. When technologies and scientific facts are presented to the world, they appear fixed and non-negotiable. However, in the process of

becoming stabilised as facts, they go through a period of contestation and controversy. For ANT, controversies are sites where social connections are traceable; therefore, they are convenient for understanding the way in which innovations are products of negotiations or translations (Latour 2005). ANT is concerned with the study of change, and the way in which something becomes 'stabilised' into its current form. As pointed out by Star (1991, p.38), the advantage of actor-network theory is to move from the experience that an enormous amount of resources are massed in order to build technologies, 'to the fact that "it might have been otherwise" – there is nothing necessary or inevitable about any such science or technology, all constructions are historically contingent, no matter how stabilized.' Actor-network theory highlights the alliances behind technical choice, and, within these alliances, the exertion of agency. As Callon (1986, p.216) notes: 'To speak for others is to first silence those in whose name we speak'. For this reason, ANT points out that there are always 'spokespersons' of a technology who engage in an arduous process of translation.

Translation is a central concept in ANT, and, simply put, pertains to marshalling people and resources to back up a claim so it becomes fact (Latour 1987). Callon (1986) distinguishes four moments of the translation process: problematisation, interessement, enrolment and mobilisation. Problematisation means framing an issue so that the actor who is framing becomes an 'obligatory passage point' to the people who are interested. However, people might not know they are interested, and this is the point of interessement: the roles and identities of the different actors must be defined so they see the need of this particular idea, product, innovation or similar entity (in this case, offshore wind technology). Enrolment is the result of successful interessement. As actors negotiate the necessity of the entity at hand, they must convince and test the roles of each involved party so that agreement and conformity with the initial 'problematisation' are achieved. Mobilisation includes more people into the actors' 'project' and involves a more widespread acceptance of the entity outside the initial 'circle' of involved actors (Callon 1986). These four 'moments' are neither consecutive nor simultaneous; they appear throughout the translation process, and each 'moment' may be drawn on at any point in time. Displacement is a central concept in translation, because at all stages in the process, actors, goals, interests and objects are displaced in order to conform to the initial problematisation (Latour 1983). This displacement is necessary in order to promote the role of the actor – or spokesperson of the technology.

A common understanding of innovation is an invention that is taken into use. With this definition, innovation only exists if it is 'stabilised' and accepted by people. By better understanding the practices that innovators are involved in, we may say something about the reason some inventions get stabilised while others do not. This is a recurring topic in the work of Latour (e.g. 1983; 1987), as he frequently refers to skilled and cunning innovators such as Pasteur, Diesel or Edison, and the way in which they were able to mobilise resources and people to support their ideas. Let us consider the example of 3M's Post-it notes to illustrate this point. Spence Silver was a 3M scientist who, through experimentation, discovered the weak glue that eventually became the innovative Post-it notes (Garud & Karnøe 2001). Working in a company that produced 'glue that sticks', Silver was relatively unclear what the weak glue would be useful for, but he was sure he had 'a solution looking for a problem' (ibid., p.13). Silver met resistance or indifference everywhere he went with his glue, but he did not give up trying to find a problem that would complement his solution – problematisation. With time, Silver managed to convince one fellow scientist of the usefulness of the glue, and ten years after the discovery, a third scientist, Art Fry, also became interested (ibid.) – interessement. Together, they explored different uses of the glue, such as putting weak glue on an entire board so that paper notes could stick to it, but 3M colleagues were not impressed.

It was not until one day, after having mixed up his pages at a choir practice (so the story goes), Fry came up with the idea of putting a bit of glue on small sheets of paper and the idea of Post-it notes as we know them was shaped (ibid.) – enrolment. From this point, the notes gained momentum and the three scientists were able to mobilise more people. Failing to convince their marketing colleagues, they decided to give away free samples of the small yellow notes to all of the personal secretaries of 3M and even competing firms (Akrich et al. 2002b). Soon, the secretaries started asking for more, and this finally caught the interest of the marketing division of 3M and, eventually, the company directors agreed to give the product a go (Garud & Karnøe 2001) – mobilisation. Finally, in 1976, twelve years after the glue was discovered, the Post-it note was mass-manufactured (ibid.).

This short example shows how 'failed' glue was transformed through a series of displacements; 'it is not failed' → 'it might be used' → 'it is useful'. Innovation can be interpreted as this process of translation and displacement that renders something useful to others by aligning interests and goals (Latour 1987). In this process, successful enrolment of

both humans and non-humans was a criterion for success: had the glue turned out to be poisonous, had Silver been fired, had the glue board idea been a success, had Fry not been an avid choir singer and so on, the Post-it might not have been created. What we see in this case is a co-production of the object and its environment through a slow process of linking glue, yellow paper, users, distributors and procedures. The invention is not selected by its environment, as evolutionary innovation perspectives claim (Nelson & Winter 1982); rather, 'the environment is produced at the same time as the innovation that it is going to judge' (Akrich et al. 2002b, p. 211). This co-production requires the spokespersons of the technology to be convincing and persistent. Such spokespersons cannot be perturbed by the obstacles they face along the way, but must turn resistance into new opportunities and new allies so that circumstances are no longer unfavourable. For this reason, Akrich et al. (2002a, p. 218) say that 'the innovation which succeeds is the one which comes to master it by choosing good speakers'. These speakers, in turn, delegate agency to intermediaries, such as the weak glue that Silver, the spokesperson, believed in and trusted. Nevertheless, there is always uncertainty connected with intermediaries, and the innovator can 'never completely know who or what they are representing, and whether indeed they (intermediaries) really are representing them' (ibid., p.222). Problematisation, interessement, enrolment and mobilisation are highly uncertain processes that require skill and time in order to successfully create a path for a new technology.

Latour (2005) introduces the central concepts of 'mediators' and 'intermediaries' to explain ANT. An intermediary is defined as 'what transports meaning or force without transformation: defining its inputs is enough to define its outputs' (Latour 2005, p.39). In other words, an intermediary may be taken for what it is. Mediators, on the other hand, 'transform, translate, distort, and modify the meaning or the elements they are supposed to carry'. Mediators are therefore more interpretive, and do not carry a fixed meaning that is easily and faithfully transported. What distinguishes ANT from other theories of the social, Latour claims, is that ANT does not take social aggregates as intermediaries – signposts that carry meaning – but as mediators that only as rare exceptions are understood as intermediaries. Mediators may here be interpreted as actors, whilst intermediaries can be 'anything passing between actors which defines the relationship between them' (Callon 1991, p.134).

The twist is that mediators and intermediaries may also be hybrids, meaning that they may in one situation appear as an intermediary and later appear as a mediator, and vice-versa. The task at hand is therefore to understand whether entities are behaving as mediators or intermediaries, and this is a matter of empirical investigation (Callon 1991). In other words, intermediaries are representatives that render displacements easier, and they create bridges, or equivalences, between two previously unconnected items that result in the designation of spokespeople (Callon 1986). These representatives may be things, numbers and figures – for example statistics showing that fishermen are suffering from decreasing yield, and are thus in need of scallop farming. Technologies, things and non-humans can therefore be taken to be masses that help hold an actor-network together.

Intermediaries may also be specialised agencies that act in the interest of technology spokespeople, such as experts, consultants or advisory agencies. In this latter case, the distinction between spokespeople and intermediaries is more blurred, as intermediaries also act in self-interest and become spokespeople of the technology when their business model is based on support of a specific technology. If we take this as a point of departure to understand technology transfer, for instance, technology 'adoption' can be understood to be synonymous with adaptation because its need and use must be constantly negotiated between the spokespeople of a technology and the surrounding community in order for it to spread (Akrich et al. 2002a; Akrich et al. 2002b). Following this logic, it makes more sense to talk about technology translation rather than technology transfer. In the case of China's offshore wind industry, this insight may be interpreted as an attempt by technology spokespeople to push procedures and practices on China. In other words, China would not be 'imitating' Western firms, but rather accepting some aspects of a technology and negotiating other aspects, and ending up with a locally negotiated hybrid.

There are also other ways to show that a lot of work is needed for a technology to come into existence through actor-networks. Latour (2004) draws a distinction between matters of fact (or objects/technologies) and matters of concern (or Things). A Thing is seen as a gathering – an arena for contestation, negotiation and agreement – whilst an object is what is 'out there, unconcerned by any sort of parliament, forum, agora, congress, court' (ibid., p.236). This distinction shows that scientific facts and technologies only exist in their present form because they were first matters of concern. As Latour (2004, p.247) puts it: 'all objects are born things, all matters of fact require, in order to exist, a bewildering variety of matters of

concern'. [2] Rather than accepting matters as facts, we should look at them as matters of concern that are open and inclusive arenas in which participants (humans and non-humans) can gather, instead of limited and black-boxed objects. ANT, in this light, can be seen as a process of detecting 'how many participants are gathered in a thing to make it exist and to maintain its existence' (Latour 2004, p.246). For this reason, Latour (2005) talks about assemblages, wherein new associations are made between humans, non-humans, knowledge, practices and organisations, and technologies emerge as stabilised entities.

Assemblages require a lot of work by all involved human and non-human actors in order to be linked together. This type of work happens continually, on an ad-hoc basis, and it is performative, i.e. it 'shape[s] actors and actors' relations as well as their practices and understandings' (Hojem and Lagesen 2011, p. 124). In other words, assemblage may be understood as a process of 'recursive self-assembling in which the elements put together are not fixed in shape, do not belong to a larger pre-given list but are constructed at least in part as they are entangled together' (Law 2004, p. 42). A central argument for Latour (2005, p. 247) is therefore that the social is 'but a moment in the long history of assemblages'. However, we do not deliberately and knowingly work to uphold an assemblage. We are always, as Latour points out elsewhere, 'slightly surprised' by our actions (Latour 1999, p. 281). We should therefore understand assemblage as a tentative and hesitant unfolding, which is 'at most only very partially under any form of deliberate control' (Law 2004, p. 42).

If we take these insights from ANT on how constellations are brought and held together by actors (human and non-human) and the associations between them, we arrive at an understanding of knowledge and learning that is markedly different from the one introduced by innovation system scholars. If knowledge is co-produced by the actors and their actor-worlds, then learning can be understood as an enactment of knowledge, or knowing-as-displacing (Law 2000). This type of learning can be understood as the enactment of different types of knowledge, in different locations. As Law (2000, p. 354) puts it, an ANT understanding of knowing-as-displacing 'recognizes that its subjects and objects are no longer fixed but are better understood as shifting and elusive processes'. In other words,

[2] What above was termed 'intermediaries' is here similar to 'matters of fact', and these are, in turn, often referred to as 'actants': human and non-human entities that describe a network, or 'black-boxes' that are circulated, moved and acted upon by actors. Similar to the relationship between mediators and intermediaries, actors may sometimes be actants, and vice-versa.

learning can be understood as a heterogeneous process that is part of a mutual inclusion with other enactments and that is characterised by uncertainty. With such an understanding, learning is relative: what type of knowledge is necessary where, for which purpose and to whose reality does this knowledge belong? Knowledge can in this perspective not be viewed as an ideal type to strive for, but must in each case be studied empirically by understanding the strategies and actions of the actors in question.

Star (1991, p.52) points out that: 'Power is about whose metaphor brings worlds together, and holds them there.' By using ANT, the task at hand for this thesis is to trace the various ways in which something is accepted or taken for granted, such as standards, procedures and practices, and the various ways in which what is taken for granted may be a product of the 'spokespersons' behind a technology. The task is, in other words, to try to uncover whose metaphors are important, and why. What negotiations take place between new users and old providers? What translation strategies are used? Before I go on to describe how ANT informs the findings of this thesis in the cross-cutting analysis section, I examine the ways in which conceptualisations of innovation in STS and innovation systems approaches can be compared and contrasted. This is useful in order to discuss the way these perspectives can highlight different and equally important aspects of innovation. Again, I must stress that I do not aim at unifying these perspectives into an overarching theory of innovation, but rather point out how they can examine the same phenomenon and highlight different aspects in the process. This might be particularly true in the case of China's offshore wind industry, since China is attempting to catch up with Europe in this industry and apparently wants to imitate certain Western institutions and organisations. However, at the same time, as several of the papers of this thesis show, the Chinese industry wants to do things their own way and define an independent path of innovation.

The STS and innovation systems approaches to innovation emphasise different aspects of the innovation process. ANT focusses more on action and change, whilst innovation systems and transition perspectives pay greater attention to institutional conditions (Sørensen 2010). However, as pointed out by Russell and Williams (2002), the boundaries between innovation systems theories and STS have become increasingly blurred. Some of the overlap is, for instance, found in the innovation systems accounts of 'the search for solutions as a bounded heuristic process, the local, tacit and cumulative character of knowledge, path dependency in directions of change, and choices and trade-offs between

contradictory pressures' (ibid., p.41). Innovation systems theorists would agree that innovation cannot be viewed as a linear process and that invention, innovation, development and so on are all part of the same process. And as already mentioned, the multi-level perspective can be considered an attempt to bridge innovation systems theorisations with STS and ANT (Geels 2007). This is, for instance, evident when attempts are made to explain the way in which technology and society are one, and therefore should be referred to as 'sociotechnical' (Geels 2002). As already pointed out, innovation systems literature argues that innovation in a firm depends on 'extensive interaction with its environment' (Fagerberg et al. 2005, p.20), ANT emphasises that innovation does not involve only firms, but innovation is also co-created with its environment. In order to illustrate the differences between ANT and innovation systems approaches I choose to focus on the MLP, since it has already a quite established figure used to visualise the framework. The differences between ANT and the MLP can be illustrated in the following way.

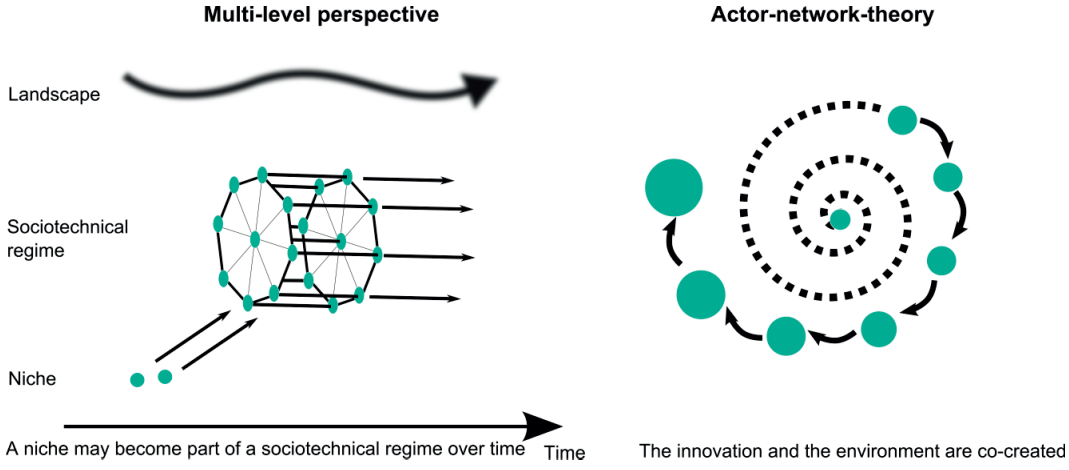

Figure 5: Differences between the multi-level perspective and actor-network theory

The ANT illustration is characterised by what Akrich et al. (2002a) call the 'whirlwind' model that draws on new associations and shows how new actors and actants are enrolled. In this way, the environment is created simultaneously with the innovation. The MLP illustration is based on Geels' (2002) model and emphasises the way in which the sociotechnical regime is a relatively fixed system that changes with time. As we move upwards in the figure, things become more and more ordered, moving from a micro- to a macro-perspective. In this system, firms face pressure from the environment (the regime and

landscape) that may shape their choices and restrain innovation, as explained previously. ANT, on the right, is 'flat' whilst the MLP, on the left, observes from the 'side' in order to recognise levels of hierarchy. Because of its evolutionary background, the focus for the MLP is the way in which a regime prevails over time, and how niches may move into and shape or change a regime. For ANT, there is a constant interaction. People and things circulate depending on who enrols whom. There are no levels, meaning that transactions and change are products of the formulations of the involved actors and not 'pressed' onto them by a regime. To be sure, both figures are greatly simplified, and they are only meant to illustrate some aspects of each approach.

We could say that the main difference between ANT and the sustainability transitions perspectives is the fundamental perspective on how change occurs (or not occurs): ANT focusses on how people and things constantly and recurringly work to assemble a fact or a concept that may become stable. Hence, the focus is often on processes produced through controversy that may or may not lead to stabilisation. In the MLP, the focus is turned on its head: Things tend to remain the same, within sociotechnical regimes, and only a massive effort can induce change. Thus, the focus is often on how a sociotechnical regime is overtaken or change because of forces from the 'outside'. In ANT, order is something that must be created, but is always threatened by dissolution, whilst in the MLP order already exists, so it must be destroyed and rebuilt. To summarise, the ANT approach can capture controversies that, when settled may lead to innovation, but controversies may continue because the parties involved are innovating on their turf. Sustainability transition approaches are more static but better at seeing the larger picture and linkages between domains that may facilitate or complicate innovation.

In this dissertation, I draw on insights from both lenses to understand how an offshore wind industry in China is unfolding. This will be done by comparing the empirical findings from China's offshore wind industry with certain statements and views within each perspective. A keen reader might ask how it is possible to let perspectives with such different ontologies inform the same topic. My response to this question is that this is how the thesis has evolved. Similar to how it is challenging to see both the duck and the rabbit at the same time in Wittgenstein's famous duckrabbit example, I agree that it can be challenging, indeed confusing, to think with different worldviews at the same time. Nevertheless, as I started out with this PhD I had been trained within innovation systems thinking, and I became more

and more introduced to STS perspectives as time went by. In view of this, the effort in this overview and tie-up essay may be understood as a way of explaining my approach to studying China's offshore wind industry. Although I would say that I today have a closer affinity with STS perspectives on innovation than with the innovation systems perspective, I believe my learning-process has been of great benefit to the analysis presented in this thesis. It has taken me through a process that has given me a richer understanding of how innovation can be viewed, something that also was useful during data collection (I will return to this and the concept of 'abduction' in the methods section'). By taking the reader through a similar voyage in this overview and tie-up essay, I hope that the following cross-cutting analysis will make more sense and provide a new and thought-provoking perspective.

The next section continues by discussing the way in which the findings of the four papers of this dissertation can be informed by the theoretical perspectives presented. How does China's offshore wind technology development unfold, and how can this process be understood and conceptualised in a Chinese context?

Cross-cutting analysis: Creating a world after whose image?

> The bourgeoisie, by the rapid improvement of all instruments of production, by the immensely facilitated means of communication, draws all, even the most barbarian nations into civilisation. The cheap prices of commodities are the heavy artillery with which it batters down all Chinese walls, with which it forces the barbarians' intensely obstinate hatred of foreigners to capitulate. It compels all nations, on pain of extinction, to adopt the bourgeois mode of production; it compels them to introduce what it calls civilisation into their midst, i.e., to become bourgeois themselves. In one word, it creates a world after its own image.
>
> Marx and Engels (1848), *The Communist Manifesto*

Marx and Engels' manifesto has an air of urgency and drama to it. Although it has been almost 170 years since it was written, with certain amendments for language we might agree that the above quote has some truth to it; today, a capitalist (or bourgeoisie) world order prevails. In this world order, it appears, in spite of 66 years of Communist Party dominance, China is no exception. Recent book titles, such as *Playing Our Game: Why China's Rise Doesn't Threaten the West* (Steinfeld 2010) and *China Goes Global: The Partial Power* indicate that China has entered the world stage and now plays by 'our rules' (Shambaugh

2013). ‘We’ refers to ‘the West’, or developed countries. On whose terms has this development happened? Has ‘the West’ created a world after its own image, and has China been a mere adopter? Or has China been ‘battered down’ and forced to capitulate? If we look further back in history, we would perhaps agree that the four famous Chinese inventions – gunpowder, paper, the compass and the art of printing – were not forced upon other nations. In the same vein, the papers of this thesis suggest that something more is going on than simply ‘receiving’ and ‘being forced’ technology, or even having technology ‘transferred’. China appears to be paving its own road, attempting to set terms for the journey ahead. In this journey, behind some of the more visible ‘toll stations’ and ‘border controls’, a negotiation of and struggle for influence is taking place. These ‘renewable’ struggles are what this thesis attempts to better understand.

In terms of theoretical approaches, paper 1 uses concepts that have been developed to explain governance in China and, along with paper 2, is more inspired by institutional or systems views of innovation. This is partly because, as I started out with this PhD, I had just written a master’s thesis about China’s onshore wind industry development, using the technological innovation systems (TIS) perspective (Bergek et al. 2008). Moreover, when studying China, institutional approaches are tempting because they at first glance appear to describe the situation quite accurately. This is particularly the case since Chinese policy makers that developed long-term plans for indigenous innovation appear to have been directly influenced by innovation systems research (Gu et al. 2009). Papers 3 and 4 are more in line with science and technology studies (STS) understandings of innovation. Turning towards STS perspectives was a relatively natural step for me to make, as I became more familiar with these types of perspectives on innovation during the course of my PhD work. None of the papers use conceptualisations from the sustainability transitions perspective directly, but are nonetheless influenced by this line of thinking, for instance on how future-orientation impacts action today (paper 4). The sustainability transitions perspective is therefore introduced here in this overview and tie-up essay. This opens up for a broader discussion of how the Chinese government can influence innovation processes in China’s offshore wind industry, and on how niches may be understood in a Chinese context.

In an attempt to draw some conclusions from all four papers seen in relation to each other, this cross-cutting analysis section reviews the contributions of each paper and explores their illumination of four topics. These four topics arise from the previous theoretical discussion

of innovation systems and institutions, STS perspectives on innovation and the role of the government. The four topics are:

1) 'Chinese institutions of technological learning', which explores the ways in which institutions of learning may be described with respect to China's wind turbine experience. In this section I discuss how the lessons from innovation systems literature can be understood in a Chinese context.
2) 'Experiments, niches and learning', which assesses the ways in which the concept of strategic niche management may be understood in the Chinese offshore wind sector. This section examines how the sustainability transitions perspective fits in the context of China's offshore wind industry, and outlines how Chinese offshore wind actors appear to learn through experimentation.
3) 'State of the art and the arts of the state', which identifies the ways in which the Chinese Communist Party is central in navigating space for offshore wind technology. This section discusses conceptualisations from sustainability transitions perspectives and ANT, and aims at describing a Chinese offshore wind industry arena that is highly impacted by the crafts of the Chinese government.
4) 'Controversy and innovation strategies', which illustrates the ways in which controversies impact innovation in China's offshore wind industry. This section discusses conceptualisations from ANT and attempts at illustrating how China's offshore wind industry unfolds seen through this perspective.

In each section I aim at providing empirical and theoretical lessons, as well as an explanation of how each topic relates to the research questions set out at the beginning of this overview and tie-up essay, namely: How does China's offshore wind technology development unfold, and how can this process be understood and conceptualised?

1) Chinese institutions of technological learning

In the section on innovation systems, I introduced a difference between institutions (taken to be forces such as norms, regulations and heuristics that structure and coordinate human activity) and organisations (such as firms, universities, government agencies and similar entities). Papers 1 and 2 of this dissertation provide an overview of the types of organisations and institutions that facilitate the growth of China's onshore and offshore wind industries; paper 3 goes more into detail on the role of foreign organisations and institutions, and also illustrates the management and financial structure of a typical offshore

wind project in China; and paper 4 assesses Chinese institutions of government. Paper 1 shows that various organisations and institutions are important in developing China's onshore wind power industry, beyond formal laws and regulations; the Chinese government appears to engage in a process of policy learning characterised by fluctuations between fragmentation and centralisation. At the beginning of the onshore wind industry development, local governments were, for instance, allowed to approve wind power projects, but as the development took off, approval was centralised. Nevertheless, the centralisation process was not simply changed from one day to the next. Rather, paper 1 shows that the Chinese Communist Party orchestrated a 'campaign' that also involved the state-controlled media, the career prospects of firm managers and the leashing of large state-owned enterprises (SOEs). Policy learning was also characterised by experiments that were scaled up as prices and internal policymaking processes were fine-tuned. To summarise, paper 1 makes a strong case for the Chinese government's ability to experiment and learn in order to get policies right and to constantly adapt to new situations.

The findings of paper 1 suggest that there is something lacking in a typical innovation systems perspective on learning when applied to China's wind industry. Various government instances are involved with a substantial process of policy learning in China's wind industry, indicating that the government has a larger role than simply as a user and producer of innovation through government support schemes. Moreover, the claim that firms are at the centre of an innovation system appears unfitting within a Chinese context. It appears, rather, that a complex set of interactions between government and industry actors defined the development through channels as wide ranging as the media and the personal career of managers. This is also apparent in the analysis of papers 2 and 4. Such a presentation of technology development is similar to the 'bricolage' story presented by Garud and Karnøe (2003), but has some differences. Rather than a modest and steady micro-learning process co-shaped by several involved actors, the Chinese example exhibits a massive centralised effort to set up experiments and test-sites that catered for steep learning curves and rapid development. It is tempting to call it a 'breakolage' approach that combines breakthrough with learning on several levels. Policy learning in this respect represented a type of reflexive governance where policymakers showed an effort and ability to adapt to and shape the rapid pace of changes within the onshore wind industry.

Paper 2 attempts to better understand what others have seen as a catching-up process – defined as a process of learning technological capabilities – in the offshore wind industry. The paper takes as a point of departure the idea that good quality is inherent in the definition of innovation, seen as interactive learning between user and producer. In many ways, quality can therefore be taken as a proxy of the amount of learning that occurs in a firm, because practices that ensure quality are inherent to the procedures that create the product. Drawing on these definitions, paper 2 points out that there are certain challenges for Chinese companies' considerations of quality as they learn to master offshore wind technologies. These challenges are connected to the ties between suppliers and manufacturers in the supply chain, when ties are either too close or too shallow. Too close ties are established relationships characterised by close 'friendships' or 'duty', wherein the buyer and seller are guaranteed. In both cases, the need for improvement is either ignored or not recognised. Too shallow ties are characterised by relationships that are short-term, where the buyer was 'shopping' for suppliers, or 'arrogant'. Arrogance in this respect means that the supplier does not care to take feedback into consideration because it considers itself an 'expert' within a different but related industry.

Large SOEs are particularly prone to have either too close or too shallow links that can limit learning processes, because such links could potentially occur through all four of the identified relationships; 'friendship', 'duty', 'shopping' or 'arrogance'. In fact, paper 1 and 2 both point out that there are certain downsides to supporting large and centrally governed state-owned enterprises (SOEs). Protection of domestic state-owned firms did not unambiguously help the development of China's offshore wind industry. In other words, the mobilisation of large amounts of resources and alliances is not sufficient if certain aspects of the technology are not mastered, because the technology may not work as intended. Although the role of SOEs is unfortunate in some respects, there are several aspects that make SOEs important. For instance, paper 3 and 4 both indicate that the Chinese environment caters for the independence of Chinese firms. Paper 3 explains that there are local policy processes that can only by dealt with by Chinese firms, and paper 4 points out that uncertainty of the future can best be dealt with by larger firms that have the financial means to allow capacities to be idle over time. In effect, this means that SOEs are particularly fit to survive in the Chinese environment. In addition, the papers point out that state-owned enterprises have ample access to resources, opportunities to diversify into new industries and important government connections, and that they support local suppliers

(although impatiently) and are generally able to draw on competencies acquired in related industries in different branches of the company. With all their flaws, SOEs can be seen as important nodes for institutional change in China (Nolan & Wang 1999), and hence, important to support a renewable energy transition.

The identified close and shallow ties are interpreted as a failure in feedback practices rather than a failure in 'understanding' a technology or how to innovate. In other words, the papers of this thesis do not identify 'weak social capital' as claimed by Gu et al. (2009, p.385) who apply an innovation systems framework to understand learning in Chinese firms and sectors. They find that weak social capital is reflected in a 'low level of willingness by either academia or business enterprises to interact, cooperate and engage in knowledge sharing with individuals and organizations' (ibid.). This appears to be another point were innovation systems thinking is not satisfactory in the context of China's offshore wind industry development. By going into a more detailed analysis of relationships between suppliers and buyers, we have seen that there is no lack of willingness to interact. Instead, we may say that interaction practices are not optimal according to a given standard. This finding is also supported by a recent in-depth study from China's onshore wind industry of the technological capabilities of Dongfang Electric Corporation (DEC), a large centrally-governed SOE (Gong 2014). Gong (2014) argues that DEC's R&D staff considered interaction with their suppliers crucial in order to learn and create a high-quality product. Limitations to learning were found to be lacking resources and personnel to perform the testing. These obstacles appeared to be manageable but still challenging. Regardless of large support from the government, certain practices were not optimal in ensuring that products performed according to expected standards.

Thus, rather than saying that actors did not engage in knowledge sharing, we could say that priorities were different. A 'high-quality' product would require a certain type of interaction, but we may well imagine other priorities that were equally important for the involved actors at a certain stage of development: cost, security, education, political relevance and so on. Within the innovation systems literature, only one perspective – the firm perspective – is important, but there are several other sides to a story that may impact innovation processes. These implications are for instance apparent when looking at the role of European certification in the Chinese offshore wind industry. Since standards are frequently taken as reference points, guidelines or benchmarks for good quality, one way of

measuring technological catch-up is by assessing the degree of convergence with established international standards. In order to testify to good quality, a global system of certification, accreditation and standards is put in place. Certificates are a specific type of audit, typically performed in the office, whereby documents, manuals and procedures are reviewed by an independent third party (Gustafsson & Tamm Hallström 2012; Gustafsson & Tamm Hallström 2013).

Paper 2 establishes that Chinese firms seek to produce offshore wind turbines that correspond to the quality of turbines from European firms. We may therefore say that European heuristics, expectations and practices are somewhat imprinted on Chinese firms. However, as paper 2 also highlights, certificates of quality conformity are unimportant in terms of actual procedures, but make a difference in terms of 'face value' that gives companies with foreign certificates an edge. Since Chinese firms see the European standard as a quality benchmark, turbine manufacturers are able to circumvent the time-consuming certification process by opting for 'quasi-certificates' that are satisfactory to the project developers. To Chinese firms in the offshore wind industry, certificates are therefore as much status symbols as they are important for improving product quality. Paper 3 also shows that European certification and advisory companies make an effort to enrol Chinese companies into their criteria of product performance and certification. The established standard – and with it, the quality-agenda – is therefore not only 'transmitted' to Chinese firms, but certification and advisory agencies also 'push' it on Chinese firms.

Within innovation studies, various types of intermediaries functioning as knowledge brokers have been proven important in technology development as facilitators of knowledge exchange and learning processes (Bessant & Rush 1995; Howells 2006; Kivimaa 2014; Watkins et al. 2014). The innovation systems approach typically defines intermediaries as people or organisations that adapt a technology to better fit with user need. These can be 'retailers, IT professionals, managers, organisers of trials, and pioneer users within adopting organisations', and they 'play a key role combining universal technical knowledge with local knowledges of the organisational and cultural context of use' (Russell & Williams 2002, p.67). Paper 3 finds evidence that intermediaries coming from abroad may not be as important to China's offshore wind industry. Certification and advisory agencies were some of the first European agents to become involved with the learning attempts of Chinese offshore wind firms. As early movers, the European service companies realised that the

value of their knowledge would decrease with time, as Chinese firms learned more about offshore wind technology. These agencies appear to be intermediaries, as defined within the innovation literature, but they may also be interpreted as hybrids: on the one hand, they are 'obligatory passage points' for Chinese companies to gain certification; on the other hand, they are mediators that attempt to enrol Chinese actors into a global system of certification and standards. Intermediaries may, in other words, also be seen as mediators that promote their own interests (Rohracher 2009; Pollock & Williams 2010).

Paper 3 argues that local employees of these European companies are better at assessing the situation at hand than are European managers, as the local employees try to adapt the European services to local needs. However, the Chinese industry resists the efforts of European companies to become 'obligatory passage points' in the process of developing offshore wind. Chinese companies apparently want to walk the path alone in order to ensure their own learning. The insights from paper 3 are telling in terms of how we should look at catch-up: instead of Chinese firms catching up with European firms and European firms 'providing' technology, we may rather observe an attempted interessement and enrolment of Chinese actors by European ones. In other words, within innovation systems thinking standards, certification and intermediaries assume an important role in innovation processes in Europe. However, in the context of China's offshore wind industry standards and certificates are ambiguous and highly political instruments that not always are carried out in the 'great spirit' of innovation. Hence, instead of identifying the Chinese lack of interest in certificates as a 'failure' on the part of Chinese offshore wind companies, we may understand it as a struggle for independence. Altogether, this means that learning efforts of Chinese firms must not only involve the acquisition of 'tacit' and 'codified' types of knowledge, but must also make assessments of what knowledge is necessary for their purpose and what knowledge is not.

Overall, the above accounts demonstrate that, as we go into more detail of studying the development of offshore wind and the strategies of the various actors involved, two related points can be made. 1) China is not copying an existing system, but attempting to create something independent, and 2) innovation in a European context is not the same as innovation in a Chinese context. These two points are related because as European companies understand successful practices through their previous experience and evaluate a potential Chinese success through the same criteria (i.e. they fear that Chinese companies

will copy them), they commit the 'crime' of thinking that innovation is the same in China as it is in a European context.

In order to survive in a global business environment, Chinese companies strive to create windows of opportunity that make them special. Nahm (2014, p.186) argues that Chinese solar and wind firms have not:

> emulated technological leaders but have specialized in innovative capabilities unique to Chinese firms. These contributions of Chinese wind and solar firms to the development and commercialization of high-technology products in global production networks break with patterns set by firms in other East Asian economies, which long produced cheap replicas of established products before catching up to the technological leaders in the West.

Nahm (2014) therefore proposes that Chinese companies have contributed unique opportunities for commercialisation that have benefitted the global solar and wind industries, and that the strategy of Chinese companies can be described as performing 'innovative manufacturing'. Hence, we may look at Chinese catching-up processes as contributions that add something and link existing knowledge and practices in new ways. This has also been pointed out by several recent studies (Nahm and Steinfeld 2014; Rein 2014; Vinig and Bossing 2015). Based on my own analysis and these accounts, I therefore propose that we start to understand the catching-up process as a learning process that engenders unforeseen opportunities, wherein much negotiation takes place according to a multitude of interests.

To summarise, innovation systems thinking tends to use European innovation 'boxes' for Chinese innovation phenomena, and is therefore only to a certain extent suitable to understand and adequately conceptualise innovation in China's offshore wind industry. We find that Chinese companies are attempting to do things independently from European firms, and the Chinese government is not only attempting to accommodate for the learning processes of Chinese firms. Rather, the government is also adapting and learning, similar to how transition management describes reflexive governance. The Chinese government does not attempt to maximise control and attain a complete knowledge of the field, but is geared towards continued learning as events develop. This type of reflexive governance is what we may regard as policy learning, which distinguishes the Chinese approach from characterisations within innovation systems literature. Does this mean that the Chinese government is catering for renewable energy industries according to the claims of the

'sustainability transitions' literature? In the next section, I will look more closely at the way in which some of the tenets of the sustainability transitions literature resonate with the Chinese experience.

2) Experiments, niches and learning

China's emerging offshore wind industry might be understood through the lens of strategic niche management, which would see it as a niche that needs to be protected and nurtured in order to grow. This protection can, for instance, be in the form of a government subsidy. History shows that state support is crucial in the nursing phase of a new technology's development (Kemp 1994; Jacobsson 2011). An illustrative example can be taken from the US, where nuclear and fossil energy technologies have historically received larger government subsidies than have renewable energy technologies:

> the federal commitment to [oil and gas] was five times greater than the federal commitment to renewables during the first 15 years of each subsidies' life, and it was more than 10 times greater for nuclear. (Pfund & Healey 2011, p.6)

More generally, Smith and Raven (2012) find that, in transition processes, protection of niches has three distinct (but simultaneous) properties: shielding, nurturing and empowerment. Shielding and nurturing are important in most accounts of strategic niche management, and Smith and Raven's (2012) contribution is on the aspect of empowerment: how actors create new associations and make a larger number of people and groups interested in the technology at hand – similar to actor-network theory's description of innovation.

Papers 1 and 2 show the way in which various institutions and organisations have shielded and nurtured onshore and offshore wind turbine development. Paper 3 indicates that Chinese companies want to take more action and be an active part in the innovation process, and not only rely on European procedures. This can be interpreted as another form of safeguarding domestic interests. Paper 4 finds that a protective space has been created in China's offshore wind industry, as exemplified by the ambitious government development targets that have been set. It appears, however, that the dynamics of niche management are different in this (catching-up) context. Rather than filling a nurturing and empowering role, state support in China's offshore wind industry was seemingly important until companies were expected to learn on their own. Thus, although a protective space for offshore wind technology was

created and shielded, nurturing and empowering was instead left open and up for definition. This is what paper 4 calls a 'strategic waiting game' characterised by ambitious government intentions but ambiguous signals of implementation.

Approaches within sustainability transition studies, such as the multi-level perspective (MLP), define actors that are operating within a sociotechnical regime. However, in some empirical studies, it has proven difficult to distinguish actors as being confined uniquely to the realm of the concepts 'niche', 'sociotechnical regime' and 'landscape' (Shove & Walker 2007; Jørgensen 2012; Åm 2015). The papers of this thesis highlight that 'niche' actors in China are also, to a great extent, established state-owned enterprises (SOEs), often with experience in fossil fuel industries. In other words, they may be classified as actors from an established sociotechnical regime. As paper 4 illustrates, the Chinese government and industry function more as collaborators in offshore wind technology empowerment than as competitors. The government is interested in sustaining the growth of offshore wind technology, and established state-owned industry actors will not actively counter this proposition. The industry is concerned about the details of how projects should be carried out, and provides checks and balances on government visions and ambitions. In other words, it is not only that small offshore wind niches engage in active enrolment of the established actors, but that 'regime' actors are also actively involved in 'interessing' and enrolling niche actors.

Rather than evaluating Chinese industry actors within the offshore wind segment on basis of their potential status as 'protected spaces' or 'niches', it might make more sense to look at the ways offshore wind industry actors approach the industry. In the interview data underlying this thesis there is a general consensus amongst both Chinese and foreign actors that Chinese offshore wind firms 'take the bull by the horns' with an attitude of trying first and improving afterwards—they 'first do it, then solve it' (Kirkegaard 2015, p.372). To use a Norwegian expression, they attempt to build a boat while at sea. The Chinese approach is related to their use of experimentation as a strategic procedure to fine-tune policy, as has been pointed out by other scholars (e.g. Heilmann 2008; Kirkegaard 2015). As paper 1 proposes, experimentation is an important avenue for policy learning in China's wind industry. Moreover, papers 2 and 3 illustrate that Chinese industry stakeholders – who often ignore foreign service providers with knowledge and experience in offshore wind technology – above all want to gain first-hand experience. Simply put, European service

providers that want to manage risk do not succeed in China because Chinese firms are not interested in managing 'European' risks. Chinese offshore wind firms are interested in learning by conducting own experiments.

Indeed, it appears as though the Chinese government's management approach that allows for experimentation creates problems more quickly, and thereby induces learning to happen more quickly, as well. Kirkegaard (2015, p.373) demonstrates this 'appropriate lack of planning' in China's wind industry, and argues that through this lack of planning, 'China has been forced to be innovative in solving them [problems that occur], and thus to learn faster'. The Chinese government, in other words, lays the foundation for this strategic emerging industry, but does not deal directly with the nitty-gritty of exactly how the road ahead should look. If we return to Latour's concepts 'matters of fact' and 'matters of concern', we may say that the Chinese state sets a direction that appears as a matter of concern. As this is done, the state allows industries to move in a more sustainable direction, and expect matters of fact to appear later. In a European context, an 'appropriate lack of planning' would be deemed a highly risky approach, but, in China, the risk is considered part of a larger learning experience. This is not to say that Chinese firms blindly plunge into new projects without an idea of how it could work and be profitable. Rather, there is an interest in trying things out, and dealing with problems as they occur. Hence, a protected space where all perceived risks are identified and attempted catered for can limit learning opportunities. Put differently, Chinese offshore wind firms are not interested in an overprotected space.

In general, we may conclude that the distinction made between levels within sustainability transition studies makes less sense in a Chinese context, since forces moving towards a 'new' regime originate as much from within the regime as from within 'niches'. The role of SOEs is especially important in this respect, given their size and amount of support and involvement with the Chinese wind industry. Should niches not be relatively small constellations with less-influential actors? If this is the case, then China's offshore wind industry is not a niche, but may perhaps be better named a 'development arena' (Jørgensen & Sørensen 1999; Jørgensen 2012), an 'experimental point' (Heilmann 2008a; 2008b), a 'sustainability experiment' (Berkhout et al. 2010; 2011) or a 'strategic emerging industry', as the Chinese government itself emphasised in the twelfth five-year plan (Bound et al. 2013). No matter what we call it, it can be described as a prioritised arena that allows for

experimentation, but with efforts made to learn quickly and build new strategic industries to provide electricity and produce economic growth.

In the next section I take a closer look at the 'arts of the state' in China, and whether these can be described as state of the art with respect to accommodating new ventures and developing China's offshore wind industry.

3) State of the art and the arts of the state

> A strong state is as dysfunctional as a weak one if it uses its power only to enrich itself. Amsden (1989, p.148)

In examples of technological catching-up processes from Japan, Korea and Taiwan, the role of the state is evident to such an extent that the term 'developmental state' has been coined to explain their experiences (Amsden 1989; Stubbs 2009). More recently, the importance of the government in developed economies has surfaced. Mazzucato's (2013) book, *The Entrepreneurial State*, expresses the importance of the state to pave the way for private business in innovation processes. As she points out:

> when organized effectively, the State's hand is firm but not heavy, providing the vision and the dynamic push (as well as some 'nudges' – though nudges don't get you the IT revolution of the past, nor the green revolution today) to make things happen that otherwise would not have. Such actions are meant to increase the courage of private business. (Mazzucato 2013, Kindle loc. 495–496)

To Mazzucato, an 'entrepreneurial state' is seen as a steward that facilitates innovation. The concept of the 'entrepreneurial state' has recently been adapted to China, where it is affirmed that the government assumes an 'entrepreneurial' (i.e. catering for technology innovation) rather than 'developmental' (i.e. catering for manufacturing-led growth) role (Sun 2015). In the following, I examine the practices that constitute what I have termed the 'arts of the state', and then discuss how these compare with transitions management and other concepts that address the role of government in industry development processes.

The Chinese government caters for new ventures on the one hand and, on the other hand, thinks about long-term plans. This not only fits well with Mazzucato's description of an 'entrepreneurial state', but also with the notion of transition management that combines elements of long-term planning with incrementalism. As identified by Smith et al. (2005,

p.1506), visions of the future play an important role in transition management literature, as visions fulfil at least five different functions: 1) they create a 'possibility space'; 2) they can act as 'heuristics'; 3) they are 'stable frame[s] for target-setting and monitoring'; 4) they can be metaphors for 'building actor-networks'; and 5) they can be 'narrative[s] for focusing capital and other resources'. This appears to be similar to the role the Chinese government assigns to what paper 4 terms 'sociotechnical imaginaries'.

Paper 1 shows that the development of China's onshore industry was facilitated by clever statesmanship by the Chinese Communist Party, entailing policy experimentation, implementation and learning. The paper finds that some characteristics of China's energy governance cater for protracted decision-making, but that fragmentation of authority, in some cases, may be beneficial in order to escape deadlock. However, policy learning alone does not sufficiently describe how movement into new initiatives is enabled; mobilisation of expectations and visions is also important in order for technologies to succeed. Paper 4 supports the findings of paper 1 and shows that the Chinese government, by drawing on the future, is able to orchestrate the development of offshore wind technology, in spite of expectations of high costs and protracted development procedures. This is further carved out in the 'sociology of expectations' framework (Brown & Michael 2003; Borup et al. 2006). Paper 4 addresses this topic and scrutinises the way in which the Chinese Communist Party, through negotiation with industry actors, has been able to mobilise the future into present-day action. Looking into the future in order to assess its potential development trajectory is a craft the Communist Party has perfected since the first five-year plan was launched in 1953 (Heilmann 2008a). Today, as these words are written, China is marshalling much energy on drafting its 13th five-year plan, which will run from 2016 to 2020 (Yale 2015).

Paper 4 emphasises that the Chinese government has quite ambitious development targets for the future, but remains rather ambiguous in relation to concrete support schemes for offshore wind. Ambiguity and uncertainty appear to exist in other countries with ambitions to develop offshore wind technology – for instance, Norway (Heidenreich 2014). There are, however, several interesting differences between Norway and China in this respect. On the one hand, although uncertainty and ambiguity also exist in China, industry actors are certain that things will happen 'soon'. Offshore wind has become a topic for the very top of government, so involved actors attempt to position themselves before 'take-off'. In Norway, on the other hand, although several firms within offshore oil and gas are interested in

offshore wind, the commitment from the government is unstable and rather unsupportive (Normann 2015; Hansen & Steen 2015). In China, therefore, expectations and imaginaries set out by the government work as loose planning tools that are relatively concrete but still leave room for negotiation, whereas in Norway, plans are vague and change frequently. Chinese firms would be certain that something would happen soon, and were not dwelling on questions of 'if' it would happen, but rather 'how soon' and 'how much'. Hence, offshore wind technology in China is not only a 'protected space', but also an 'expected space'.

Although it appears that the 'niche' concept does not fit with the Chinese situation, transition management theory and the reflexive governance concept resonate rather well with the way in which the Chinese Communist Party has been able to accommodate for wind turbine technology. Transition management has developed its conceptualisation with the intention of advising governments on managing a transition away from a carbon-intense economy (Rotmans et al. 2001). But transition management portrays a rather idealised picture of how experimentation is driven by joint problem-solving, and it disregards how politics can be a nasty process dominated by powerful actors and their interests (Voß and Bornemann 2011). Transition managers are not neutral and do not necessarily represent sustainable projects (Shove and Walker 2007). Picking technologies and supporting certain actors will have political implications. In the case of China's offshore wind industry we might on the one hand say it is easier for latecomers to pick winners, as latecomers have more knowledge of how well an emerging technology may work, and thus opting for renewable energy technologies only after seeing that they can be profitable. On the other hand, there are several arguments that speak to the Chinese Communist Party's interests in keeping the status-quo; the government has a strong interest in maintaining economic growth, providing enough electricity for its citizens and ensuring the continued legitimacy of the Communist Party. In this consideration, it is also very likely that sustainability, in terms of reducing the pollution around major cities and reducing environmental impacts from coal power, plays an important role in the motivations behind the Chinese government's support for offshore wind technology (Ydersbond and Korsnes 2015). Moreover, it is certainly not a risk-free endeavour to develop offshore wind technology. Hence, there is a heterogeneous set of concerns and conflicts of interest that impact the decisions of policy makers and other industry actors.

Transition management and reflexive governance cover some important aspects that help us understand how policy learning may occur through emergent and experimental processes: If a project fails the first time, we may take that turn of events into account and learn from it in the next round. Transition management is therefore a practical and applicable guideline or set of advice for policy makers. However, it cannot be said to be a framework that helps us conceptualising innovation in China's offshore wind industry. This is particularly so, since the transitions management framework is based on the multi-level perspective designation of niches, regimes and landscape (Rotmans et al. 2001). As already discussed, these levels do not resonate as well with the situation described in China's offshore wind industry. With actor-network theory, the focus would not be on pre-existing levels, but we would rather have to ask: Who are the actors behind transition and what are their interests?

There is no shortage of scholars attempting to coin a term to explain China's transition over the past years; proposed terms include 'authoritarian upgrading' (Heilmann 2010), 'Janus-faced state-led growth' (Hsu 2011) and 'crony communism' (Dickson 2011). Most concepts hint at the important role of the state as well as the ambiguous but adaptive nature of the Chinese governance apparatus. Nevertheless, it appears to me that the only sufficient condition for innovation is constant learning and constant attempts at creating and combining new knowledge. Chinese actors are attempting to create an arena where offshore wind technology is a favourable option alongside other cheap electricity providing technologies. To create this arena, a massive work of translation of a large amount of actors, such as private and state-owned enterprises, local and central government officials and foreign actors, must be aligned with their expectations of a future offshore wind industry in China. This work is what Chinese actors have started by creating space for a new influx of ideas, actors and competencies within offshore wind technology. Instead of coining new concepts, perhaps the best we can do is to describe the 'arts of the state' and the ways in which these strategies pave the way for new initiatives in China. The 'arts of the state' in China are unique and Chinese institutions do not hinder innovation. To describe the development in the words of actor-network theory, in the case of China's offshore wind industry, the state acts as a strong agent of translation in favour of new renewable energies.

In effect, what we observe in this thesis is several actors trying to translate their interests and goals in order to align with others: the state, with vision and long-term ambition, the industry, with a more immediate and localised concern, and European advisory and

certification agencies entering China, with their own ideas of how offshore wind technology should be practiced. As Chinese actors attempt to cater for innovation, they also shape the environment that constitutes innovation. This brings us to the last topic, namely the role of controversy in innovation processes within China's offshore wind industry.

4) Controversy and innovation strategies

If we look at the findings of the four papers in this dissertation they all illustrate how different actors attempt to bring their own perspectives, needs and wants into play in China's offshore wind industry development. The Chinese government, the Chinese industry and the European certification and advisory agencies all have their idea of what is necessary in order to succeed in offshore wind technology development. All these actors work to achieve some form of stability or 'settlement' where their version of the world is represented. In other words, all these actors are part of the controversy of China's offshore wind industry development. They all impact the way in which the industry develops by engaging in this controversy, although they might not in the end succeed with their own objective.

One way of understanding this is through the concept of assemblages, as introduced earlier. The efforts of the various actors may be attempts at associating and assembling people, things and concepts that align with their own interests and objectives. As we have seen, the Chinese government actively encourages domestic offshore wind companies to engage with the industry, but is also reluctant to enrol European companies to a great extent. Competencies that are mobilised are either distinctly Chinese, or are attempted 'Chinesified', so that full ownership and credit can be given to Chinese actors. In this sense we may talk about a form of 'Chinesification' assemblage where competencies, national values, standards, experiments and risks are translated into an offshore wind technology development project. A similar strategy is for instance found in the Norwegian oil and gas sector in the 1960 and 70s, when the government played an important role not only in establishing the Norwegian company Statoil, but also in catering for research, education and demonstration, and adapting technology to Norwegian culture and environment (Sørensen 2005). Briefly put, Norwegian actors took oil and gas technology and experiences from the US and UK and adapted them to Norwegian conditions, leading to several innovations, such as the Condeep structure, sub-sea installations and horizontal drilling, which made the

Norwegian experience special (ibid.). Moreover, we cannot say that US and UK companies necessarily were negatively impacted by the Norwegian experience on a longer term. In China, we may well observe that the act of rendering technology Chinese, or 'Chinesification', can be part of a larger innovation strategy.

We may picture a competing European assemblage that is enacted in Europe and attempted re-enacted in China with actors such as the European certification and advisory agencies. In this respect, paper 3 may be characterised as a study of how the controversy plays out for these European actors. Likewise, paper 4 can give a better understanding of the assemblage that the Chinese industry is attempting at achieving in their 'negotiations' with the Chinese government. Nevertheless, it is not a given that any of these actors are able to continue their assembly work. The Chinese government does not have everything under control, and it might not continue playing a central role for a long time. Support schemes might end, companies or government organisations may seize to exist, and the work to assemble China's offshore wind industry would not continue. We may therefore ask whether or not the Chinese communist party is able to marshal enough forces to hold its assemblage together, or whether it will be manifestly changed in some way or another. In this respect, inaction is also a relevant factor to study innovation in a Chinese context.

This point takes us to the question of what type of knowledge and experience that are *enacted*; what are the important types of knowledge that are displaced and enacted in China's offshore wind industry? The papers of this thesis have given us some hints. What in a European context has been termed risky and reckless (i.e. 'they just get on and do it', in paper 3), low-quality, too ambitious or arrogant can in the Chinese case often be characterised as a difference in priority; a different appraisal of what knowledge to be enacted when. Chinese actors tend to see the European approach as over-engineered, over-protected and perhaps even somewhat arrogant (i.e. 'We are the best in China; we don't need your [European] assessment!', in paper 3). Simply put, if the whole European package would be accepted, several European actors would be attached to it, and that would be unwanted if independence is to be achieved for Chinese actors. For this reason, 'rendering Chinese' is a much more long-term strategy than a more simple 'copy and paste' strategy. The same way Norway would likely not have had the international oil-giant Statoil had Norway simply let US and UK actors do as they wanted, China aims at establishing their own domestic and independent industry. To be sure, it is not a given that such a strategy

would succeed. Moreover, we should not say that Chinese actors deliberately produce low quality products or want to be reckless. Rather, the strategies chosen reflect a different point of view and a different goal, which to European eyes appears risky, but to Chinese actors appears necessary.

Since ANT focusses on controversy, and does not take an assumed view of the world as a point of departure, it allows for categories to be redefined in the eyes of the beholder. ANT points out that there are certain downsides in simplifying how we view innovation, and this may be especially true in a new context, such as in China. Thus, ANT has enabled a better understanding of the Chinese side of the story, and why Chinese actors choose the strategies they do. Innovation in China's offshore wind industry may in this light be described as a practice that draws from and builds on assemblages. This is for instance illustrated by the specific way the Chinese government communicates with the offshore wind industry, the way that experiments and risk-taking is catered for in ways that go beyond what European companies would consider necessary, the way expectations and visions are managed and aligned, or the special role of state-owned enterprises within the offshore wind industry, as pointed out in this cross-cutting analysis section.

In the concluding section of this overview and tie-up essay, I shall synthesise some of the lessons of this thesis, and provide some hints as to what a conceptualisation of innovation in the context of China's offshore wind industry might entail.

Conclusion: a Chinese innovation arena

> The future belongs to hybridisation rather than to clearly defined lines of development.
>
> Akrich et al. (2002b, p.212)

This concluding section offers an account of what has been achieved in this dissertation, and it reflects on some lessons that can be drawn from the process. Several recent accounts have described China as innovating and developing new technologies (e.g. Steinfeld 2010; Nee & Opper 2012; Nahm 2014; Rein 2014; Wan et al. 2015). However, with regard to China's ability to innovate and create new technology, there are, as always, 'believers' and 'doubters' (Steinfeld 2010). Depending on the definition of innovation at hand and the economic sector chosen for analysis, China can be described as either a lagging or leading nation. Employing the broadest definition of innovation, China is found to innovate simply by interacting and engaging with new technologies; with the stricter definition, it is found that China does not and cannot innovate because nothing genuinely new is created. In this dissertation I have pointed out that innovation is a process characterised by learning and negotiation. In a globalised world, it is naïve to believe that China will become fully 'independent' or able to conduct purely 'indigenous' innovation. However, it is equally misleading to think that China simply copies technology from foreign countries, and that the learning process ends with that.

What we observe in China is a process of development that impacts the rest of the world. Thus, rather than talking of independent innovation, we should talk about interdependent innovation when describing China's development strategy. The nuances of this interdependent innovation process need to be elaborated on and described more accurately. This thesis sets out to present this kind of detailed analysis of the innovation processes, the trails and nitty-gritty aspects of change in China. Thus, the main contribution of this dissertation has been to provide a more detailed picture of where the locus of change can be said to be, what actors are important and how learning takes place. China appears to be going in a direction that is deliberately chosen, and one that is planned, but still 'appropriately unplanned'. The contribution of this dissertation is a richer understanding of the innovation process of an emerging technology – offshore wind – within a catching-up country, China.

By describing and drawing from approaches from innovation systems standings, sustainability transitions and actor-network theory, this thesis contributes to understanding better the way in which change toward more sustainable technologies can be understood and conceptualised in China. This overview and tie-up essay has critiqued the way in which technological learning has been conceptualised through 'technology transfer' and 'catch-up'. The 'catch-up' term implicitly contains several assumptions related to the experiences of northern Europe and the US since the industrial revolution. If we focus on what has consistently been found amongst catching-up countries – namely that they create new opportunities – we arrive at a relatively simple definition of catch-up: the knowledge that a potentially profitable industry exists and the learning process accompanied with this knowledge. This definition is not far from Schumpeter's definition of innovation as new combinations of existing knowledge. The critique of catch-up in this dissertation therefore culminates in an analysis of learning and innovation in China, drawing on empirical data from China.

In this concluding section I provide some empirical as well as theoretical lessons as to how China's offshore wind technology development unfolds, and how can the process be understood and conceptualised. To start with the more empirical findings, at least four conclusions can be drawn from the papers of this dissertation, based on the study of offshore wind technology development in China:

- The Chinese government has a central role in accommodating new ventures and has ambitious goals and high expectations for offshore wind technology development;
- Chinese institutions are characterised by flexibility, supporting or constraining enterprises that to a varying degree are controlled by the central government;
- Chinese offshore wind firms are exploring several avenues of interdependent technology development, ranging from licensing, joint-ventures and mergers and acquisitions to own experimentation;
- Experimentation is found to be an important learning strategy that provides competencies and experiences to Chinese firms, but that involves higher risks. Experimentation is also an important tool for policy learning and policy development.

These four conclusions were identified and discussed in the preceding cross-cutting analysis section. From this discussion, we can pinpoint four more theoretical lessons to studying China's offshore wind industry development:

- Innovation systems thinking tends to use European innovation 'boxes' for Chinese innovation phenomena, and is therefore only to a certain extent suitable to understand and adequately conceptualise innovation in China's offshore wind industry;
- Transitions management is promising, and reflexive governance appears to describe the Chinese government's experimental policy learning approach rather well. However;
- The distinction made between levels within sustainability transition studies makes less sense in a Chinese context, since forces moving towards a 'new' regime originate as much from within the existing 'sociotechnical regime' as from within 'niches';
- Actor-network theory provides a better understanding of the Chinese side of the story since it addresses why Chinese actors choose the strategies they do. Innovation in China's offshore wind industry may therefore be conceptualised as a practice that draws from and builds on different assemblages.

With these conclusions as a basis I propose some initial characterisations of what I would call a Chinese innovation arena. In China's offshore wind industry, Chinese actors can often choose to accept things as they have been defined by 'frontier' actors, but instead choose to challenge them and take risks. This is perhaps most clearly the case with European certification and advisory agencies, but it is also a general finding throughout the thesis: Chinese actors take risks to learn. Naturally, many actors choose safe strategies aimed at rapid economic growth and shiny new factories, as discussed in paper 2, or what I called 'copy and paste' strategies in the previous section. Nevertheless, contrary to my initial expectations, a general eagerness to engage in trial and error prevailed in many of the interviewee accounts. Thus, none of the papers identify so-called 'acidic attitudes towards the new and untried' in China (Baark 2007, p.354), which was elaborated by what I term the 'no' side to whether or not innovation occurs in China. Instead, Chinese actors appear to be avid learners, willing to take chances and quick to seek and create new opportunities. This is defining of a Chinese innovation arena.

Instead of 'indigenous' innovation, we may conclude that certain elements of offshore wind technology development in China hint at a form of 'Chinesification' of technology that renders competencies and processes Chinese. Mazzucato (2013) defines entrepreneurs as actors who are willing and able to take on risk and genuine uncertainty. She describes the US as a case wherein the state supported research, development and commercialisation of new technologies in very early phases (such as technologies that were used in the iPhone). In the Chinese case, we observe strong state support of industrial innovation and

manufacturing of technologies that already exist elsewhere. Nevertheless, as we have seen throughout this dissertation, the Chinese government and industry actors are also willing and able to take on risk and uncertainty. This risk is related to the uncertainty of rendering technologies and practices Chinese, and whether or not something new will come out of it in the end. Attempts at innovation usually fail, which is why innovation activities always are embedded with risk.

Innovation in China's offshore wind industry may be conceptualised and understood as a practice that draws from and builds on assemblages. Such assemblages are held together and shaped by the efforts of a heterogeneous set of actors with diverging aims, ambitions and interests. This is illustrated by the specific way the Chinese government communicates with the offshore wind industry, the way that experiments and risk-taking is catered for in ways that go beyond what European companies would consider necessary, the way expectations and visions are managed and aligned, or the special role of state-owned enterprises within the renewable energy industries, as pointed out in the cross-cutting analysis section. Hence, a Chinese innovation arena as described through studying the offshore wind industry can be considered a space where experimentation, learning and exchange of knowledge and experiences eventually will lead to innovation.

Having outlined the findings of this thesis, I now end with some concluding reflections on the extent to which China's offshore wind development represents a transition towards something that is more environmentally sustainable. We might for instance expect China's energy industry to be characterised by path dependency, as caused by a technological paradigm that influences learning processes. For instance, Unruh and Carrillo-Hermosilla (2006, p.1189) make the case that 'carbon lock-in may become globalized and that large developing countries, if they are successful at rapid industrialization, will become carbon copies of their industrialized neighbors'. Although China, on the face of it, looks like a 'carbon copy' with large investments in coal, gas and oil, the nation is investing more in renewables than is any other country in the world (FS-UNEP 2015). For this and more reasons, several authors have recently agreed that the world is moving towards a 'green revolution', to which China will contribute – and is already contributing – at the forefront (e.g. Mazzucato 2013; Hu 2014; Mathews & Tan 2015).

Depending on our definition of sustainability, we can discuss whether the offshore wind industry development is part of a larger transition to a more sustainable China. Focussing

uniquely on energy supply, the scale of investments in non-fossil energy sources (including nuclear power) are now larger than those in fossil energy; more non-fossil electricity generation capacity is added each year, and non-fossil electricity power generation increases quickly, whilst fossil power generation decreased in 2014 (Mathews & Tan 2015). These are on the one hand indications that China is moving rapidly towards more non-fossil electricity sources. Offshore wind energy, seen in this context, is part and parcel of a larger transition, and the success of offshore wind technology in China may affect the success of other renewable energy sources, as well. Moreover, the institutions, organisations and practices related to onshore and offshore wind identified in this thesis are similar and relevant to other renewable energy technologies in China.

On the other hand, since rapid growth comes with a price, several cautions should be pointed to. China's economic turnaround that increased incomes and the national GDP has also involved decades of environmental abuse, destruction of limited natural resources and widespread pollution of air, soil and water (Shapiro 2012). In paper 1, it was indicated that the onshore wind industry once faced severe overcapacity issues, and the government had to tighten its leash on the industry. Such problems of excess capacity have not only been found in China's wind industry, but appear to be a more general element in China's technological catching-up strategy (Rock & Toman 2015). For instance, the overcapacity in iron and steel industries in China in 2014 represented the total iron and steel capacity in Europe (ibid., p.250). Another downside with this large focus on added industrial capacity is a decreased focus on product quality and long-term performance, as papers 1 and 2 address. If Chinese companies generate overcapacity in order to learn, and in that learning process produce lower-quality products, the sustainability of China's renewable energy transition can be jeopardised.

To provide some concluding reflections, I can say that the process of studying China's offshore wind industry has been a journey that started out with a rather fixed understanding of what innovation entails; an innovation system understanding. This is perhaps most evident in paper 1, which is based on my master's thesis, using the technological innovation systems approach. When I started out trying to understand how innovation came about in China, I experienced an increasing sense that the innovation systems approach did not fit well with the Chinese offshore wind experience. I did notice that there were large investments in research, the government had set up large development areas outside the

coast of Jiangsu province, and several companies were entering the wind industry. Chinese companies were trying to acquire technology from European companies and used all the means they could to learn. But did this mean that they were innovating? Moreover, in the eyes of European companies, Chinese companies were only copying them, not interested in quality, taking too many risks and so on. There were several sides to the same story. Who were right?

As I got more familiar with the strategies of Chinese and European companies, I found out that they all had different goals and diverging approaches. European companies were for instance afraid that they would one day be out of business, as Chinese companies continued to learn. As I also became more acquainted with the science and technology studies literature, I felt that it could provide me a richer set of nodes to base my analysis on. It allowed me to include a larger set of actors and motivations. At the outset of my PhD work I was also rather excited about the sustainability transitions framework, and I attempted finding out how I could employ it to help explain what I had found during my fieldwork in China. Ultimately, however, it was not entirely satisfactory, and it felt unnatural to describe the situation in China's offshore wind industry through the perspective. Naturally, innovation in a Chinese context cannot be accurately described by one PhD thesis alone. A collective academic effort is necessary to better understand how innovation may be described in a Chinese context. I would nevertheless say that the journey I have gone through has been enriching and has given me several insights that I surely would not have acquired otherwise. Hence, the resulting analysis is what has been presented in this overview and tie-up essay, and I hope that it has been of use and has inspired a new and different way of thinking about innovation in a Chinese context. I now proceed to outline my methodological approach.

Methodology

From the very beginning the goal with this PhD was to gain a better understanding of how China's offshore wind develops, as well as to try to understand how Norwegian experiences with maritime and oil and gas industries could be of any use in China. As is evident at this stage, the latter part of this aim, namely the Norwegian part, has been replaced with a more European focus. As I set out, I my aim was quite wide: to approach as many people as possible that had any knowledge and experience with China's offshore wind industry. Such actors could be local and central government officials, employees and managers of offshore wind turbine manufacturers, consultants and certification engineers, people working with electricity grid for wind turbines, developers of wind farms, suppliers of coating for wind turbines, or someone working with wind resource assessments and the optimal placement of wind turbines. The list could continue. My plan was to heed Latour's (1987) advice: to follow the actors. What did the involved actors consider important topics? Who did they think were important to talk with? My data collection period in China can thus be described as a somewhat desperate attempt to follow actors within China's offshore wind industry. I shall now provide some more details of how this attempt to follow actors unravelled, and what type of challenges and complications I encountered.

This methodology section was the last thing written in the research project. It may seem as if the three years of PhD work went smoothly, with everything planned and any potential deviation taken into consideration. The truth is that the research process was messy and not always following an overarching 'grand plan'. I operated with early ideas and enthusiasm that were magnified, transformed or killed along the way. When I started out, I had just finished an M.Phil where I used technological innovation systems (TIS) as the main theoretical basis, and I knew next to nothing about what people referred to as 'STS', science and technology studies or science, technology and society. The papers of this thesis very much reflect the learning curve that I went through over the three years as a PhD student in STS. The first paper is a rewritten version of my master's thesis and was influenced by my experience with innovation systems theory. The next three papers were more informed by my exposure to STS approaches. According to Gubrium and Holstein (1997), method is about making informed choices and not shying away from complexity and analytic tension. The choices researchers make 'cannot eliminate the complexity or tensions, but they can specify how we will deal with them, and what opportunities we will sacrifice or reject'

(ibid., p.110). Here, I will explain the choices I made, but I am sure that many equally viable choices could have been made.

A general principle that guided the data collection period was to avoid an application of overarching explanations, so that preconceived hypotheses could be confirmed to be rejected. I attempted to follow data-defined leads, which were also informed by theory. I also attempted to let the qualitative data shape the outcome and focus of my research, simply because the data 'knows' better. My approach was therefore similar to that of a pragmatist (Clive et al. 2004) and inspired by constructivist grounded theory, seeking to continuously learn, compare, interpret and analyse during the entire process, from data collection to writing up (Charmaz 2006). Originally, grounded theory methods were developed by Glaser and Strauss at the end of the 1960s; they started with the data and developed theory inductively, maintaining a strong foundation in the empirics. A literature review was supposed to be conducted only after an 'independent' analysis was developed, in order that the researcher's thought process would not be influenced (Charmaz 2006). Later, the two authors departed in their view of grounded theory: Strauss developed a more interpretive version of grounded theory, allowing for verification along with data collection, and Glaser stayed true to the method of discovery through empiricism (ibid., p.8). Subsequent developments of grounded theory, such as those from Adele Clarke (2005) and Kathy Charmaz (2006), have tried to 'push' grounded theory around the postmodern turn and adapt it to a more constructivist ontology and epistemology. Postmodernism, in this sense, is understood as 'the doubt that any method or theory, discourse or genre, tradition or novelty, has a universal claim as the "right" or the privileged form of authoritative knowledge' (Richardson, quoted in Clarke 2005, p.xxvi). Clarke and Charmaz served as inspiration for my application of grounded theory tools on situation-specific analysis, emphasising research as an ongoing process and giving no formal theories as an ultimate goal. Therefore, although a general point of grounded theory is to discover and develop theory, I used the theory as a set of principles and guidelines, and not as a fixed and prescriptive approach.

In short, a constructivist and postmodern approach means that positivist attitudes to research are abandoned and a more reflexive stance is acclaimed of the researcher's role in data collection, interpretation and analysis (Gubrium & Holstein 1997). With an empirical approach, the quality of the data, to a large extent, determines the robustness of the study.

According to Charmaz (2006), rich, suitable and sufficient data is a pre-condition for successful completion of a grounded theory approach. In my case, what was considered 'rich', 'suitable' and 'sufficient' was much based on my own gut feeling, depended on the type of data I could access and was re-evaluated as my research questions changed throughout the process. In order to avoid forcing the data into an existing framework, it was important that I kept an open mind when selecting and engaging with respondents. Hence, instead of a purely inductive or deductive approach, the concept of 'abduction' proved useful in invoking a certain researcher's attitude when entering the field.

According to Reichertz (2007, p.216) 'abduction is intended to help social research, or rather social researchers, to be able to make new discoveries in a logically and methodologically ordered way'. Abduction does not imply a simple combination of fieldwork data and existing knowledge in the field; rather, abduction is a process that occurs when there is no appropriate explanation for an occurred phenomenon. This process happens inside the mind of the researcher, and it is therefore a 'cognitive logic of discovery' (ibid., p.220). This means that both field data and existing theory are allowed to influence the researcher, but, ultimately, instead of forcing either the theory or the data into an uncomfortable framework, the researcher must disconnect and leave space for his or her own logical reasoning. As Reichertz (2007, p.221) puts it:

> Abductive reasoning is (…) an attitude towards data and towards one's own knowledge: data are to be taken seriously, and the validity of previously developed knowledge is to be queried. It is a state of preparedness to be taken unprepared.

For grounded theory, this means that new hypotheses can appear at any stage of the research. The researcher must make an effort to stay open and not conclude or shape a theory too early. Put differently, the researcher must avoid premature emplotment (Kirkegaard 2015) and make sure not to enrol in the metaphors of those who have the power to create them (Star 1991). I have tried to follow this advice when working with the data.

This dissertation is based mainly on data collected in Shanghai between May 2013 and April 2014, but it also uses data collected in Beijing between August and December 2011, as well as interviews in Norway in early 2013. The data mainly consists of interviews, but it also includes a two-month period of participant observation in Shanghai, as well as attendance at several industry conferences and workshops in China and Norway between 2011 and 2014. Although I originally planned to collect several other data, such as surveys

and conduct shadowing – or 'structured observation' as Czarniawska (2007) calls it – lack of time and access were central reasons I ended up with the data that I have. When I started this PhD project in 2012, I did not have much knowledge of offshore wind, but I had just finished a master's thesis on China's onshore wind industry, titled 'The Growth of a Green Industry. Wind Turbines and Innovation in China'. Many of the experiences, contacts, data and knowledge I gathered in that project were carried on in the work of this dissertation. I now proceed to describe the data collection in China and analysis processes.

Doing fieldwork in China

Right before my first interview was conducted with the CEO of a small private Chinese enterprise in Shanghai, my interpreter and I went through the questions I wanted to ask. One of the questions was: 'Why did this company decide to enter the offshore wind industry?' My interpreter thought this was a silly question. 'Why would you ask that?' she said. 'Isn't the answer quite obvious? I mean, there is a market opportunity, so of course the company decided to enter. And if this company had not done it, for sure there would have been another company entering. I really don't understand why you would ask this.' I tried to explain that we couldn't really know that until we asked, but she was not convinced. At another event, we were going through the questions for an interview and I explained that I wanted to know how the various companies acquired their knowledge. My interpreter retorted as if it was the most obvious thing in the world. 'Puh! By studying, of course!' Her point was clear; what a waste of time to ask questions with such obvious answers! Indeed, many times I had the feeling that what I was doing was perhaps too simple; I was asking childish questions that were obvious to everyone but me. A general experience, however, was that when asking questions with genuine curiosity, things that initially seemed obvious were not as clear as they first appeared.

As this opening paragraph describes, several issues related to cultural and language differences influenced the data collection process. I will return to some of these issues below, and provide some reflections on what this could imply in the section called 'Limitations and reflections'. I now proceed to present the data gathered during my fieldwork in China. What I refer to as the 'fieldwork' comprises the whole stay in China, including the interview data, participant observation and information that were gathered

throughout. I start by describing the participant observation before providing details on the interview sampling process and the interviews.

Observation and participation

During the stay in China, I participated at several workshops, conferences and industry exhibitions that were useful in gathering data. During many of these events I would take notes or record memos in order to remember what I learned. This information was valuable at later stages, either during the interviews or in the writing-up process. I also conducted a two-month participant observation in a European firm. From the start, I hoped to follow a Norwegian company that was attempting to enter China's offshore wind industry; however, this proved quite a difficult task. First, the offshore wind industry is still quite small and not many Norwegian companies are in place in China. Second, I lacked the contacts who could introduce me to a company. Third, there was little benefit to a small entering company from having a researcher hanging over their shoulders whilst they struggled to gain a foothold in one of the world's most impenetrable markets.

I therefore almost gave up hope of finding an appropriate company, and focussed mostly on getting enough and high-quality interviews with relevant industry stakeholders within and outside of China. By chance, however, I got in touch with the employees of a European certification and advisory company at a wind energy conference in Beijing. They had an office in Shanghai and were eager to get a better overview of the prospects and stakeholders of China's offshore wind industry. After hearing about my research, they agreed to meet with me in Shanghai to discuss the possibilities of what they called a 'secondment'. During the meeting, we discovered our rather overlapping interests. We therefore agreed that I would write a report for them, would participate in meetings, workshops and company dinners and would interview employees. My title at that company was therefore 'Project Manager', and I was seen by many as a consultant who would stay at the office. The stay lasted two months and proved the most valuable experience of my stay in Shanghai. Not only was I able to gather more information about the industry, but I was also able to get new interviews with stakeholders that I otherwise would not have had the right contacts to meet with. The stay at this firm functioned as a gateway to new interviewees through people who had good contacts, which has proved to be the best way to get new contacts in China. During the stay at this company I took notes daily and recorded my thoughts about as they

occurred. These notes were also included in the consecutive interviews, coding and analysis of the data.

Sampling interview data

Sampling data is all about locating the right number of excellent research participants. 'Excellence' here simply means that the interviewees possess experience, either direct or indirect, of the phenomenon under study, and are able and willing to convey this experience. Locating these people is of central importance, but it is not as straightforward as one may think. During the fieldwork in China, what I considered the 'right' people changed often, and I had to start over with more general sampling strategies as soon as I defined a new area of interest. Each phase therefore required a substantial amount of pondering, and I could not proceed mechanically. Indeed, finding the right people to talk to is a craft in itself, and is very much dependent on the individual skills of the researcher. Morse (2007) points out that grounded theory enables the researcher to develop concepts in stages and phases, and that sampling strategies should change in concert with each phase. In this respect, my one-year research stay in China was useful and necessary in order to go through the various stages: as I learned more about the industry, I began new rounds of sampling based on wishes to explore certain topics that became increasingly interesting and 'pressing'. Such topics for me included the view of quality in the learning phases, the role of the government and perspectives on the future.

Morse (2007, p.235) highlights four sampling strategies that change during the research process: convenience sampling, wherein research participants are selected according to accessibility; purposeful sampling, wherein participants are selected based on the analysis of the previous data; theoretical sampling, wherein participants are selected as theory and concepts take shape; and, finally, theoretical group interviews, which may be conducted to modify or saturate the emerging new understanding. I employed convenience, purposeful and theoretical sampling during my stay in Shanghai. Morse explains that, during the process, data should be coded and recoded according to the developing curiosity of the researcher. In my experience, I found that the occurrence of these phases was quite unorganised, and I went back and forth several times before I was sure of my own reasoning. For example, an interview conducted in an early phase unexpectedly became an interesting theory-generating interview in a later phase, as soon as the data were interpreted.

And vice-versa, what I considered a potential theory-generating interview sometimes pointed me in an unforeseen direction, serving as a guide for a new idea requiring new sampling and interpretation of the existing data.

In China, access to information and relevant interviewees can depend on the sensitivity of the research topic. Heimer and Thøgersen (2006, p.15) point out that political sensitivity in China 'becomes a question of timing as well as the audience and the use of the information'. Having conferred with experienced researchers in the field of energy and China before I entered the field, I established that renewable energy is not a sensitive topic compared to issues relating to for instance nuclear power. The renewable energy industry appeared to be a field China wanted to display widely, and it was not as difficult as expected to locate and contact relevant people. Rather than the sensitivity of the topic, what proved to be a barrier to access was the interviewees' schedules and availability combined with the small gain for interviewees to use (or waste) their time with me. This combination initially led to an ethical dilemma: it appeared, based on the few contacts I had, that potential interviewees wanted something in return for their participation; for instance, they wanted their company to be mentioned several times (favourably). Fortunately, this conflict of interest did not become a real problem after the interviews were booked and conducted. Interviewees generally appeared to enjoy talking about their work and visions of China's sustainable future, and they appeared to be genuinely interested in answering my questions.

Booking interviews in China requires flexibility on the part of the researcher. In my case, making appointments further into the future than one week was generally difficult, and most appointments were of the type: 'Just call me next week when you are in town and we will set an appointment'. Interviewees were also very flexible with regards to the exact time of the interview, and an appointment would often be on 'Tuesday morning' or 'in the afternoon around 2'. This flexibility at first appeared strange to me, but in almost all cases a meeting took place as 'planned'. This flexibility was very convenient on days when I had booked several interviews and was uncertain about exactly when I could be at each place. The easiest way to get an interview was through the so called 'snowball' sampling method, whereby I asked my interviewees to introduce me to colleagues or other relevant people. At the end of each interview, therefore, I always asked if the interviewee knew of other relevant people who would agree to meet me. Often, the interviewee would pick up his or her phone and give me a list of relevant people and their phone numbers. This proved a very

useful sampling technique, as introduction through others is a strong sign of trust and status in China. In addition, my interpreter proved very useful in contacting and booking meetings with relevant interviewees. Another good sampling technique was direct interaction – for instance at conferences and industry exhibitions, where I met interviewees face-to-face and exchanged business cards. In some instances, I also used the professional networking service LinkedIn to find and contact relevant people in the offshore wind industry. Lastly, inviting people to interviews was sometimes much easier if the invitation was sent from someone with higher rank. Therefore, on some occasions, my supervisors sent invitations to higher-level government officials.

Another detail that may have been particular to China was that being young was not an advantage in booking and conducting interviews. As one of my European interviewees said when explaining how he sometimes struggled to be taken seriously by his Chinese clients: 'I would do good with some grey hair'. I found that growing a beard helped somewhat. In general, though, language was the largest barrier for both the fieldwork and the written information I accessed, although I received great assistance from my interpreters. The wind industry in China is fairly international, and many of the central actors spoke English well. Furthermore, a large number of foreigners engaged with environment, energy and business topics are situated in China, all of whom communicated with me in English. I found it convenient to engage in several classes of intensive language training while in China. I thus acquired a basic knowledge of Mandarin, which was very useful in establishing a positive interview atmosphere, as it conveyed my genuine interest. Lastly, an ethical consideration arose with regard to the interviews – namely that giving gifts is very common in China. Several people, both locals and foreigners with long-term experience in China, advised me to bring a small personal gift for the interviewee, preferably something from my own home country. I therefore took this advice and decided to bring each interviewee a small Norwegian chocolate as well as a very small bottle of Norwegian aquavit. This was regarded as a common courtesy by the interviewees.

Interviews and the interview situation

During my stay in China, there were several incidents when I did not behave according to expectations. One such incident was at a company I visited in Guangdong, where I was invited for lunch after an interview. I asked if it was okay for me to take a picture, and the

company representatives replied, ‘Sure, but how about we go outside and take it?’ I thought it was more interesting around the dinner table, and I asked the waiter to take some pictures. As she was taking the pictures I noticed that the person in charge was staring at his phone not interested in being photographed. Some minutes later, one of the men asked me why I wanted to take pictures at the table. I answered that I thought it was a cozy setting. He explained that, with the new government’s increased focus on corruption, they were worried that they would lose their jobs since the company was government-owned. I deleted the pictures and we agreed to take pictures outside, instead.

The interview situation has received much attention in qualitative research methodology because of the central position of the interviewer in a classical subject-object positivist discussion. In a constructivist approach, the focus is on the interaction between the interviewer and the interviewee. In this interaction, each party’s perceptions of the other influence the outcome of the interview, and the outcome, in itself, is a dialogue, rather than a set of facts retrieved from a source (i.e. there is a co-construction of meaning). In line with Morse’s reasoning of stages and phases, Bogner and Menz (2009) focus on the theory-generating phase of research, wherein they claim that the expert interview is most interesting. In this phase, the interviewer is not after the technical or process knowledge of the expert, but rather the interpretive knowledge (ibid., p.52).

In contrast, earlier stages of the research, wherein an overview and exploration of the field is of interest, the ‘special knowledge’ of the expert is useful, but cannot to the same extent be said to be theory-generating (ibid., p.72). Use of expert interviews therefore depended on the stage I was in. However, as Bogner and Menz (2009, p.53) point out, the types of knowledge that occur in interviews are difficult to distinguish and are ‘primarily a construction of the social scientist doing the interpretation’. Since different types of knowledge appear during the analytic procedure, I found that the ‘early’ and ‘late’ stages of the research were quite relative categories: expert interviews were informative early on, then re-appeared as theory-generating in later stages of the analysis, with new codes. The prefix ‘expert’ therefore appears superfluous to me, and I instead refer to my interviews as qualitative interviews, reflecting the social encounter in which ‘speakers collaborate in producing retrospective accounts or versions of their past actions, experiences, feelings and thoughts’ (Rapley 2004, p.16).

In the interaction, the researcher and interviewee both have preconceived perceptions of each other that emerge. Bogner and Menz (2009, p.56) find that these perceptions can be used productively, and they show that the way in which the interviewee perceives the researcher decides the outcome of the interview. For instance, if the interviewer is perceived as a colleague or fellow expert, the dialogue will take another shape than if he or she is perceived as a potential critic. Bogner and Menz (2009) identify six types of interview situations, two of which are not recommended. The two identified situations in which benefits are generally lower than drawbacks are when the interviewer is seen as an authority or a potential critic, respectively (ibid.). Situations in which the interviewer is seen as a co-expert, an expert from a different culture, a layperson or an accomplice can generally be used to the interviewer's advantage. During each interview, I attempted to notice these expectations and competence ascriptions, and use them in a way that benefitted the study. I could not do very much to change these perceptions, but I benefitted from simply knowing about the various pros and cons in each situation. For instance, I would sometimes ask rather simple and obvious questions in order to not appear as an authority, but on several occasions I felt the need to 'name drop' and use industry-specific expressions to 'prove' myself to the interviewee.

During the fieldwork in China, I conducted 43 interviews. An overview of these interviews can be found in appendix 1. In addition, papers 1 and 4 in this thesis draw on interview data that was collected in Beijing in 2011, and which was originally collected for my master's thesis. The appendix of paper 1 has an overview of these interviews. Therefore, in total, 55 interviews informed the analysis of this PhD thesis, as described in Table 1. Of these 55 interviews, 31 of the organisations (firms, associations, government bodies etc.) originate from China, 23 originate from Europe, and one is an international organisation.

Table 1: Overview of interviewees

Industry segment	Interviews	Number of interviewees		
		Chinese	Foreign	Total
Government	11	14	1	15
Turbine manufacturer	11	12	1	13
Turbine supply*	3	2	1	3
Advisory and certification	17	8	8	16
Balance of plant**	8	12	0	12
Project developer	5	9	0	9
Total	55	57	11	68

*Turbine supply includes gearbox, pitch and yaw systems and control systems.
**Balance of plant includes forecasting, electricity grid, coating, cables, installation and foundation and research/university.

In addition, 17 interviews were conducted with offshore wind companies in Norway during the spring of 2013, before I travelled to Shanghai. These 17 interviews are not employed directly in the papers of this dissertation, but they were highly informative in relation to the jargon of the industry and the status, 'state of the art' and Norwegian contributions to the offshore wind industry. On average, each interview lasted 70 minutes, ranging from 15 to 120 minutes. Most interviews lasted around one hour. All interviews were semi-structured, containing 'a sequence of themes to be covered, as well as suggested questions' (Kvale 1996, p.124). See appendix 2 for a sample of the interview guide. The interview guide was used flexibly, allowing for a change of theme that naturally corresponded with the interviewee's reasoning, and answers were followed up as appropriate. Some interviewees had prepared PowerPoint presentations, and it was sometimes difficult to explain that I was more interested in their opinions about the offshore wind industry than facts and figures. The information they provided was nevertheless useful as a point of departure to discuss concrete issues that were more interpretive. Topics that were referred to as established 'facts', such as 'the government target for 2015 is 5GW', could therefore launch discussion of the likelihood of reaching the target, the ambition of the government versus the industry and similar topics. Interviews always began with me going through the purpose of the study then clarifying the amount of time needed to complete the interview as well as my plans for using the information gathered; finally, I informed the interviewee of my policies on confidentiality and anonymity (Creswell 2007). All interviewees are anonymous in the papers of this dissertation, and the names used are fictional in order to protect the identity of the interviewees. Upon request, some of the interviewees received a copy of the interview guide before the interview.

The data was analysed and coded with the assistance of the analytical software NVIVO. The analysis was shaped by my thoughts during the fieldwork, and these thoughts were typically collected in 'analytic memos' (Saldaña 2009) that functioned as 'sites of conversation' with myself about my data (Clarke 2005, p.202). The memos were typically jotted down immediately after each interview, after larger events and sporadically throughout the fieldwork. The coding was based much on these memos and the way in which certain 'nodes' or matters of concern developed throughout. Examples of codes could therefore be anything from 'government influence' to 'future-orientation' and 'reference to Europe', reflecting my interest from the start as well as new interests that developed. 39 interviews were audio recorded and transcribed verbatim, while 15 were recorded in notes. The main reasons why some of the interviews were not audio recorded were that the particular interviewees did not want to be recorded or I judged recording unnecessary for the situation at hand. The latter was typically the case in very noisy environments or settings in which the topic was considered sensitive and I felt the interviewee would speak more freely without the audio recorder. This was particularly the case in interviews with government officials or people from state-owned enterprises such as the large offshore wind power developers.

I used an interpreter for 19 of the 54 interviews. I employed four different interpreters during the whole stay in China: One mainly in Beijing, two mainly around Shanghai, and one around Guangzhou. Three of them were professional interpreters with previous experience from renewable energy industries, and one was an English language student on master's level. These were found through web-sites, and also through recommendation by the interpreter when he or she could not meet at a given point. Use of an interpreter has both advantages and disadvantages: it allows for flexibility regarding note-taking during interviews, but also heightens the probability of information manipulation in the re-iteration (Scheyvens & Storey 2003, p.133). I cannot be sure that information was accurately transmitted. Nevertheless, most of my translators had worked for several years as professional interpreters and had held assignments within the wind industry. Based on the interpreters' experiences and professionalism (e.g. using industry-specific words), I was assured that the interviews would be interpreted as accurately as possible. Further, although all of the interviews were conducted in English, only two of the interviewees were native English speakers. Use of a foreign language may cause people to unintentionally say things they do not really mean, or may tweak the meaning of what was originally intended. The way this was dealt with was by repeating the question or the meanings when there was any

doubt, in order to confirm. I am therefore confident that the information gathered through the interviews and used in the papers of this dissertation represents the original interviewee meanings.

Limitations and reflections

As we have seen, being a Norwegian person conducting fieldwork in China led me into several situations of confusion and misunderstanding. How did my role as a foreigner in China impact the data I gathered, and how did my limited knowledge of Chinese language affect the results that I got? This is the last thing to be discussed in this overview and tie-up essay, but it is not the least important one. As a white, European male in China, you notice rather quickly that you are viewed in a different way than native Chinese. People take an extra glance at you when you pass them in the street, and they behave differently when you meet. This affected the data gathering process in at least two ways. On the one hand, it appeared easier to get access to the right people as a foreigner, because of the possibility that I might represent some important foreign organisation. This was pointed out to me by several of my Chinese friends before, during and after my stay in China. For example, one Chinese interviewee said that he was interested in contributing to my research projects because he was interested in learning more about foreigners and what topics we were interested in. On the other hand, people might not have told me how things really are. This concern is naturally prevalent in any kind of interview-based research, but in this case it might different for two reasons. We can imagine that interviewees might attempt to paint a more 'beautiful picture' because 1) I am a foreigner, or a Westerner, and Chinese might want to compare favourably to Westerners, and 2) because anything else would interfere with the official Chinese Communist Party policy.

Indeed, as pointed out by Solinger (2006), interviewing can sometimes be challenging in China, as Chinese respondents are careful about saying something wrong or out of line with official policy. Thus, although the renewable energy field itself appeared to be a relatively insensitive topic, it was clear that top-level politics typically were not up for discussion. I noticed, for instance, that several interviewees answered in a general and abstract way and left room for interpretation in their responses. Some of these 'hints' and vague utterances from Chinese interviewees could therefore be regarded as fairly strong indicators of opinions, though they might not sound like it. Some such utterances may also have been due

to a lack of mastery of English, in the cases where no interpreter was used. I attempted to deal with this challenge by asking questions in various ways or repeating the interviewee's response and asking for confirmation. Some interviewees were also worried that I would use the information in news articles or similar. In such situations it helped to reassure them that the information gathered was only for research purposes, and that it would be anonymised. Also, it was often relatively obvious if we were touching on a sensitive topic (often when talking about opinions government policy), and I would change my questions accordingly. Moreover, having written my master's thesis about China's onshore wind industry and spent 6 months in Beijing during the work with the master's thesis, gave me very good point of departure of how to conduct interviews, pose questions and interpret answers. I undoubtedly went through a gradual learning process in terms of understanding how to best communicate with and interact with Chinese interviewees and interpreters. This experience made me more confident about the quality and usefulness of the information I collected.

In general, my main method of making sure that I had relatively reliable data was to compare and contrast, or triangulate, several sources of information. These sources were written information from inside and outside of China, such as research articles, books, or online news, as well as interview data, and data from my participant observation and observation at different offshore wind-related venues. Nevertheless, I was not able to use information written in Chinese, and this is a limitation to the information gathered. In hindsight, it would therefore have been have been a great advantage for this dissertation if I were able to read and speak Mandarin Chinese fluently. Lastly, the propaganda apparatus of the Chinese Communist Party may have had a reach that went beyond any of my attempts to get reliable data. The Chinese Communist Party is an authoritarian force that may be dictating and influencing more practices than are possible to observe from a researchers point of view. In this respect, however, it is interesting to note that the people who were the most outspoken and critical to the way things were developing typically had a high-level position within either the government or state-owned enterprises. Such interviewees provided very interesting perspectives that would balance accounts from other sources. Hence, ultimately, my own intuition of what was a reliable or a less reliable account would also influence my analysis of the data.

Finally, we might also ask to what degree are the data gathered suited to answer the research questions and meet the purpose of the dissertation? As already pointed out, the research

questions for this dissertation developed as I saw the type of data I could access and as new fields of inquiry were revealed to me. Although I considered topics such as 'innovation' or 'sustainability' in China, I was simply dependent on the right data to ask the right questions. In this way, my research questions can be seen as resulting from a process of tacking back and forth between the data I accessed, the information they provided, and what I found interesting about the data. I should nevertheless explain how I addressed large entities such as the government, the Chinese Communist Party and European certification agencies, and still claim to have had a 'grounded' approach. In her attempt to move away from preconceived levels and hierarchies, Clarke (2005) understands each situation as constitutive of its own levels. As she puts it (ibid., p.71), 'the conditional elements of the situation need to be specified in the analysis of the situation itself as they are constitutive of it, not merely surrounding it or framing it or contributing to it. They are it.' In other words, I legitimately analysed these larger entities as they appeared inside the actual situation under examination. Callon and Latour (1981, p.299) formulated it in this way:

> A macro-actor is a micro-actor seated on black boxes, a force capable of associating so many other forces that it acts like a 'single man'. The result is that a macro-actor is by definition no more difficult to examine than a micro-actor.

The various actors I studied defined their worlds through their own concepts, and my interpretation of the data was shaped by interviewee perceptions that, in turn, formed my hypotheses. In this way, it was possible for me to study macro-processes within an international industry without referring to preconceived levels. The interviewer and the interviewee both refer to and conceive of these levels, in situ. Levels and hierarchies can therefore be understood to be constructed by the actors involved, and not pre-existing frames. In short, the methods taken to study offshore wind technology in China meant being respectful, to take people's accounts seriously, to be reflexive and evaluative of the relationship between the interviewer and interviewee and, finally, to constantly compare, contrast and analyse the data.

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Appendix 1: Overview of interviews

#	Date	Industry segment	Position	Origin of org.	Int. dur., min.	Place
1	03.07. 2013	Turbine manufacturer	Chief engineer	China	45	Shanghai
2	20.08. 2013	Certification and advisory	Head of renewable energy service China	Europe	60	Beijing
3	28.10. 2013	Foundation coating	CEO	China	60	Shanghai
4	30.10. 2013	Gear, Pitch Yaw	Sales manager	Europe	50	Shanghai
5	30.10. 2013	Turbine manufacturer	Business developer	Europe	120	Shanghai
6	31.10. 2013	Coating	Sales manager	Europe	50	Shanghai
7	31.10. 2013	Certification and advisory	Manager China offshore and certification engineer	Europe	120	Shanghai
8	01.11. 2013	Certification and advisory	Manager - wind energy	Europe	35	Shanghai
9	16.11. 2013	Turbine manufacturer	Director	China	120	Shanghai
10	22.11. 2013	Control systems	General manager China	Europe	60	Shanghai
11	06.12. 2013	Research/Universit y	Professor and associate professor	China	80	Shanghai
12	09.12. 2013	Certification	Certification engineer	Europe	45	Shanghai
13	09.12. 2013	Advisory	Consultant and business developer China	Europe	60	Shanghai
14	11.12. 2013	Certification	Head of Renewable energy service	Europe	60	Beijing
15	11.12. 2013	Advisory	Consultant	Europe	60	Beijing
16	11.12. 2013	Government	Director general	China	15	Beijing

#	Date	Industry segment	Position	Origin of org.	Int. dur., min.	Place
17	11.12. 2013	Government	Attaché	Europe	75	Beijing
18	12.12. 2013	Government	Deputy director general	China	45	Beijing
19	12.12. 2013	Government	Advisor	China	75	Beijing
20	12.12. 2013	Government	Executive vice secretary-general	China	60	Beijing
21	13.12. 2013	Turbine manufacturer	Offshore wind structural engineer	China	120	Beijing
22	13.12. 2013	Advisory	Consultant	Europe	60	Beijing
23	18.12. 2013	Advisory	Consultant	Europe	50	Copen-hagen
24	20.01. 2014	Advisory	Regional manager	Europe	50	Shanghai
25	26.02. 2014	Government	Deputy director and assistant	China	70	Nanjing
26	26.02. 2014	Gearbox	Account manager	China	80	Chang-zhou
27	11.03. 2014	Developer	Vice director of preparatory department	China	90	Hang-zhou
28	11.03. 2014	Turbine manufacturer	Offshore wind technical director and control system supervisor	China	75	Hang-zhou
29	17.03. 2014	Cable	Sales manager	China	60	Nantong
30	17.03. 2014	Installation, Foundation, Port	Senior business manager offshore wind	China	60	Qidong
31	01.04. 2014	Construction and Operation	Head of engineering department	China	60	Rudong
32	01.04. 2014	Turbine manufacturer	Control system engineer, offshore wind turbine	China	120	Rudong
33	02.04. 2014	Government	Section leader offshore wind	China	45	Rudong

#	Date	Industry segment	Position	Origin of org.	Int. dur., min.	Place
34	04.04. 2014	Coating	Sales manager	Europe	60	Shanghai
35	04.04. 2014	Turbine manufacturer	Technical project manager	Europe	90	Shanghai
36	10.04. 2014	Government	Director industry park development dept.	China	40	Shanghai
37	14.04. 2014	Forecasting	General manager and chief engineer China	Europe	90	Beijing
38	14.04. 2014	Grid	Assistant director of renewable energy dept.	China	90	Beijing
39	15.04. 2014	Certification	General manager of wind energy dept.	China	90	Beijing
40	15.04. 2014	Advisory	General manager China	Europe	60	Beijing
41	16.04. 2014	Developer	Technology centre, and deputy director engineer in the project and development dept.	China	60	Beijing
42	17.04. 2014	Developer	Director, production and operation dept.	China	90	Zhuhai
43	17.04. 2014	Developer	Dept. of resources development, offshore wind	China	50	Guang-zhou

Appendix 2: Sample interview guide

1) **General**
    a. What is the history behind this company?
    b. Why did you enter the offshore wind industry?
    c. What obstacles do you face in the industry?
    d. Can you describe how China's offshore wind industry has developed the past years?

2) **Specific**
    a. Commercialisation:
        i. How are the conditions for commercialisation in China?
        ii. How do companies scale up from R&D
        iii. How well does state support for commercialisation work?
    b. Technology, knowledge and competencies:
        i. How are technology and competencies acquired?
        ii. Are there any useful clusters of knowledge that your company can benefit from?
        iii. What communication do you have with foreign firms? Is it useful?
        iv. What components are typically sourced from abroad?
    c. Supply chain:
        i. Are your customers very demanding in terms of ensuring quality of products?
    d. Finance:
        i. Who are investing in this industry?
        ii. Is there a difference between government & private money?
    e. Management:
        i. What is the ownership structure?
        ii. How engaged are the owners?
        iii. How included are employees? (Hierarchy?)
        iv. What is the background of managers / owners?
    f. Actors:
        i. Who are typically interested in entering the offshore wind industry in China?
        ii. What role do the following play in the industry? How important are they?
            1. International companies
            2. Government
            3. Research agencies / universities
            4. Certification and consultancy agencies

3) Future:

a. In your opinion, how does the future look for the offshore wind industry in China?
b. Will government goals be reached?
c. What are the main drivers and barriers?

Paper 1: Fragmentation, Centralisation and Policy Learning: An Example from China's Wind Industry

Marius Korsnes

Paper published in *Journal of Current Chinese Affairs* 43(3), 175–205. Reprinted with permission.

Abstract:

This paper seeks to understand what government mechanisms have allowed China's wind industry to grow as fast as it has over the past ten years. Instead of formal rules and regulations, this paper focuses on specific sets of institutional conditions that have been crucial in the process of high-speed implementation of wind energy in China. Specifically, fragmentation and centralisation, together with policy experimentation and policy learning, have been fundamental for policy flexibility and institutional adaptability. The paper illustrates that there are benefits and disadvantages to these characteristics, and that inherent qualities of China's governing system that lead to rapid growth overlap with those that lead to challenges in terms of quality and long-term performance.

Keywords: China, policy experimentation, renewable energy policy, governance

Introduction

China's development of renewable energy technologies over the past ten years can be considered the start of a renewable energy journey. Since 80 per cent of China's electricity generation is fuelled by fossil fuels and electricity consumption is increasing rapidly (EIA 2014), the question arises of whether the People's Republic will be able to sustain the increasing energy needs of its citizens without causing irrevocable environmental damage. China's wind industry has grown from 0.8 gigawatt (GW) installed capacity in 2004 to 91 GW as of the beginning of 2014 (Li et al. 2007; GWEC 2014). This represents a velocity of capacity development never before witnessed, and has involved the coordination of interests and an alignment of institutions on a massive scale. The growth has led to many challenges, such as uncertainties over the long-term performance of Chinese turbines, transmission constraints for remote regions, lack of qualified personnel and delays in connecting wind farms to the electrical grid (Martinot 2010). Several reports and studies agree that these challenges have arisen due to a lack of coordination between stakeholders in China's wind turbine industry (e.g. Jiang 2011; Luo, Zhi and Zhang 2012; REN21 2009; Zhang et al. 2009). Nevertheless, we still lack a detailed understanding of the governing mechanisms behind the rapid growth of the wind industry.

This paper argues that a specific set of institutional conditions has been crucial for the high-speed implementation of renewable energy. "Institutions", in this paper, refers not to government bodies, but to forces – regulations, norms and heuristics – that structure and coordinate human activity. Fragmentation and centralisation, together with policy experimentation and policy learning, have been fundamental for policy flexibility and institutional adaptability. Building on the work of Lema and Ruby (2007), who conclude that coordination has been important for the growth of China's wind industry, this study looks at the processes that have led to coordination, including experimentation and scaling up. Also covering the period of 2011 to 2014, a time with slower growth, I present evidence that coordination and fragmentation are mechanisms the government takes advantage of to control industry growth. These features make China's energy governance system highly flexible and adaptive, enabling and constraining growth according to policy preferences, but the same features have also led to the considerable challenges the industry is facing.

Several recent works have addressed the relationship between institutions and renewable energy implementation in China. Some have provided general overviews and updates (e.g.

Martinot and Li 2007, 2010), some have looked specifically at the policy regime and institutions (Cherni and Kentish 2007; García 2011, 2013; Schuman and Lin 2012; Wang 2007; Zhang, Andrews-Speed, and Zhao 2013), and some have looked at innovation and technology transfer (e.g. Gosens and Lu 2013; Huang et al. 2012; Klagge, Liu, and Campos Silva 2012; Lewis 2013; Ru et al. 2012; Urban, Nordensvärd, and Zhou 2012; Zhou et al. 2012). Most of these studies highlight the explosive development of China's wind industry, and the considerable challenges this has led to. Some notable exceptions look at the institutional mechanisms on a level deeper than the formal laws (i.e. Lema and Ruby 2007; Mah and Hills 2014), but few studies show how the same institutional framework has inherent advantages and disadvantages vis-à-vis the development of the wind industry. Implementing legislation is a craft, and China's achievement in growing the largest wind turbine industry in the world in only ten years cannot simply be reduced to a set of laws. In taking a broader institutional approach, this paper seeks to understand what institutional traits have induced the rapid growth of China's wind power industry, beyond the formal laws and regulations.

The paper proceeds as follows: First I summarise the most relevant approaches to China's institutions and governance. I then introduce the methodology and proceed to give a brief overview of China's wind power policy framework and development over the last ten years. I then introduce aspects of fragmentation and policy learning that have benefitted the industry, and address the aspects of authoritarianism that have benefitted the industry. Finally I discuss the findings, evaluate the usefulness of this institutional approach in understanding China's rapid wind industry development, and draw conclusions.

Institutions and Governance in China

Flexibility, Learning and Policy Experiments

This paper looks at the development of the wind energy industry in China in light of recent theoretical contributions on Chinese governance, and it deliberately avoids using theories developed in a non-Chinese setting. I believe, as found by, for instance, Heilmann and Perry (2011), that Chinese institutions are unique and need be studied on their own terms. Scholarly discussions of governance and politics in China often revolve around tensions between centralisation and decentralisation, plan and market, local and national levels, rural

and urban environments, or industrial and agricultural settings (Dittmer and Liu 2006; Fewsmith 2010; Lieberthal 2004; Saich 2011). Observing similar tensions in China's energy sector in the 1980s, Lieberthal and Oksenberg (1988) developed the highly influential concept of "fragmented authoritarianism". Their main conclusion was that the energy policy process is protracted, disjointed and incremental. Furthermore, the fragmentation of authority creates inter-ministerial competition and disjointed policymaking, because respective ministries have a similar level of authority, but disparate goals. This means that any policy initiative or major project "need[s] to acquire the active cooperation of many bureaucratic units that are themselves nested in distinct chains of authority" (Lieberthal and Oksenberg 1988: 22). Despite the fragmentation, the very top of the Chinese political system is authoritarian and able to push through directives (Lieberthal and Lampton 1992).

Since Lieberthal and Oksenberg's thesis was developed, it has been increasingly acknowledged that flexibility, learning and adaptation have been central to China's massive transition process, and China scholars have put more emphasis on institutional capacities. For instance, Dulbecco and Renard argue that China's economic success resides in reconciling

> the permanency of a well-established institutional order required for the coordination of individual plans, and the flexibility of institutions necessary for the move towards the market (Dulbecco and Renard 2003: 328).

Gu and Lundvall (2006) highlight the importance of policy learning for China's innovation performance and emphasise the benefits of a simultaneously centralised and decentralised system. Lately, Heilmann and Perry (2011) have termed China's governing method "guerrilla policy style", with reference to the governing methods adopted during Mao's reign, and that explain how Chinese governing institutions have been able to manage sudden change and uncertainty throughout the decades.

Heilmann (2008a, 2008b, 2009) coined the concept of "experimentation under hierarchy" to describe the process by which China's institutional structure has innovated and adapted alongside large-scale economic change. Heilmann (2008b: 3) writes that this adaptability is due to a practice of policy experimentation in China that "precedes the enactment of many national policies". In short, he explains that policy experimentation, by delegating responsibility to local officials, "reduced the frictions and delays characteristic of top-level consensus-building and interagency accommodation, and helped to avoid protracted policy

deadlock" (Heilmann 2008b: 21). By starting with a smaller policy area, and scaling up only when successful, policy experimentation was a useful way to gain consensus amongst top-level politicians, since it entailed placing the policy burden on local governments and attributing the national success to the given policy (Heilmann 2008b). This experimentation can therefore be considered one way in which the fragmentation of authority is lessened.

Moreover, policy experiments are not only initiated from the top down in China. Andrews-Speed points out that "fragmentation has allowed for *local policy initiatives*, some of which have been successful and have then been taken up by the central government" (Andrews-Speed 2012: 13, emphasis added). Some policies have therefore been introduced from the bottom up. Wang (2009) argues that experimental government policy, experience and practice have been important for fine-tuning China's policy machinery. Grassroots practices, in particular, have been an important source of policy learning for the central government. Fischer (2010) argues that a combination of top-down and bottom-up policies may be the best approach for sustainability transitions, especially with reference to rapidly changing institutions. At their base most accounts of China's institutional flexibility are notions of learning and adaptation – crucial for any kind of rapid change. These notions provide a useful background to understanding governance in China, and as will become evident in the following sections of this paper, fragmentation, learning and adaptation are concepts that resonate well with the analysis of China's wind industry.

Energy Governance in China and the Portfolio Approach

Governance of the energy sector is high-level politics in China. Li (2013) points out that all the members of China's newly elected Politburo Standing Committee, as well as several previous members, have important links to the energy sector. Many of them have either made a political career through the oil and gas industry, or have been CEOs of some of China's largest oil companies. The Chinese Communist Party (CCP) is the glue that changes and dictates the direction of development (Andrews-Speed 2011). Contrary to common perceptions, China's energy governance is not strictly organised from the top down. The perception that China, with an authoritarian government, both knows and easily gets what it wants has been challenged over the past decade (Cunningham 2010; Downs 2008; Kong 2009). Energy decisions are highly politicised in China because they involve many different actors with diverging interests and objectives. This has led to a state of affairs where there is

> a "leadership vacuum" in China over energy policy and many decisions are driven by projects promoted by localities or industries rather than being guided by a coherent national energy policy (Kong 2009: 791).

Therefore, a change in energy policy amongst top-level leadership does not necessarily equate to smooth implementation throughout the system. Implementation can be constrained by vague and contradictory formulation of regulations, or because local government officials prioritise economic growth at the expense the environment (Meidan, Andrews-Speed, and Xin 2009). Thus, even though power is centralised, this does not mean that it is concentrated in the centre.

The most important body regulating wind energy policy centrally in China is the National Development and Reform Commission (NDRC). Within the NDRC, the National Energy Administration (NEA) is responsible for developing and implementing renewable energy policies, but the administration is too heavily understaffed to be completely on top of emerging developments (Downs 2008; Anonymous 3 2011). Provincial governments also have their own Development and Reform Commissions that develop and implement local policies, sometimes in conflict with policies developed centrally (Mah and Hills 2014). Other important government actors are the "big five" state-owned power generation companies, and the two grid companies State Grid and Southern Grid. The grid companies and the "big five" have much influence in terms of what projects are developed and where, and often pursue their own agendas (Andrews-Speed 2012; Rosen and Houser 2007).

Fragmentation prevails in China's energy sector, but Cunningham's (2009) seminal research shows how the government uses liberalisation and consolidation as a means to control the growth in the coal and electric power industries, in what he terms a "portfolio approach to energy governance". Cunningham finds that central ownership of the electric power industry has fluctuated over time, demonstrating less regulation in times of electricity supply shortage, and more in times of sufficient electricity supply. This has led to periodisation of rapid expansions followed by contraction. Indeed, an alternating wave of consolidation and liberalisation has, over time, characterised China's electric power facilities, depending on the central government's concern at the moment. As we shall see below, something similar can be said about fragmentation and centralisation in the wind power industry.

Method

This paper is based on twelve semi-structured interviews conducted between August and December 2011, a substantial review of relevant literature and participation at wind energy events in China since 2011. Interview informants had varied backgrounds, ranging from government officials and technical wind industry experts to company employees from large, medium and small manufacturers of wind turbines. An overview of the informants can be found in the Appendix. Several informal conversations were held from 2011 to 2014 with domestic and foreign experts and people involved in the renewable energy industry. These include wind farm developers, researchers, wind industry experts and professionals, as well as private and state-owned wind turbine component manufacturers. Moreover, important insights were collected at the following conferences and industry exhibitions: China Wind Power 2011 and 2013, Offshore Wind China 2012 and 2013, and the 8th China (Shanghai) International Wind Energy Exhibition and Conference 2014. The analysis is also founded on a wide range of second-hand literature such as reports and research articles. Many documents were accessed during the fieldwork – for instance, information from the Chinese Renewable Energy Industries Association (CREIA) or the various companies visited. Online news articles were especially useful for retrieving the latest information on China's rapidly developing wind industry.

Interview candidates were identified through online research, industry association lists and trade statistics and, most importantly, the snowball method. The underlying reasoning behind selecting particular interview candidates was to be able to map the opinions of central actors in order to paint a representative picture of important industry factors. Interviews, therefore, involved enquiry into the relevant stakeholders' perceptions of overall wind industry performance. Candidates perceived to be relevant were informed experts at universities, organisations, consultancy firms and the government, as well as wind turbine company employees. These groups were deemed relevant because of their industry knowledge and varied backgrounds in different segments of the industry. The transcribed interviews were analysed using the computer-assisted software NVivo. This software was of great assistance in coding and categorising material, allowing for systematic analysis. There are some considerations that need to be mentioned in regards to the interviews. First, nine interviews were conducted in English, while three were in Chinese, using an interpreter. Using an interpreter can make it difficult to make sure that the question has been understood

as intended, and that the answer is correctly transmitted. Second, only three of the interviewees were native English speakers. Using a second language may cause people to say things they did not really mean, or it may tweak the meaning of what was originally intended. These two caveats have been taken into account and were dealt with – for instance, by repeating the question or clarifying meanings in cases where there was any doubt. I am, therefore, confident that the following analysis represents the views of the interviewees.

Formal Institutions Promoting Wind Power in China

This section provides an overview of the formal policies that have promoted China's wind power development, divided into two main areas: those that promote industry, and those that promote electricity generation. These regulations have been discussed extensively elsewhere (e.g. Lewis 2013; Zhang, Andrews-Speed, and Zhao 2013) and will be covered only briefly here.

Industry Development

At least three important factors have directly promoted the development of China's wind industry. First, the domestic content requirement of wind turbine manufacturing in China has led to the development of supply chain markets; second, speedy approval for wind power projects at a provincial level has resulted in a huge increase in the number of wind turbines each year (Yadav 2011); and third, in 2011, China attracted 52 billion USD in new renewable energy investments, 60 per cent of which went to wind projects (UNEP, FSFM, and BNEF 2012). In that year, China attracted the most new financial investments for new renewable energy in the world (UNEP, FSFM, and BNEF 2012).

In 2002, the Chinese government decided to stimulate the development of wind energy through a national wind concession programme, allocating selected sites for wind farm construction to the company bidding the lowest electricity tariff (Recknagel 2010). Some prerequisites were made in order for projects to be accepted, such as restrictions on turbine size and local content. In effect, the price of electricity not only decided who won the bid, but also the extent to which the turbines were manufactured locally (Wang 2010). Because of a dependence on expensive, imported turbines, the Chinese government decided that a

domestic content requirement pertaining to wind turbines was needed to facilitate domestic manufacturing of turbines and turbine parts (Howell et al. 2010). During the first concession round, which started in 2003, the local content requirement of turbines was set at 50 per cent; in 2004 this share was increased to 70 per cent, and in 2009 it was finally phased out (Wang 2010). In addition to content requirements, import tariffs on preassembled wind turbines were at 17 per cent in 2007, whilst tariffs on their components were set to only 3 per cent (Martinot and Li 2007). This policy, together with the removal of local content requirements in 2009, is thought to have "allow[ed] domestic manufacturers to more easily access wind components from foreign suppliers as they buil[t] the prototypes for their larger turbines" (BNEF 2010).

Electricity Generation

Measures aimed at increasing the proportion of renewable electricity production in China are covered in the Renewable Energy Law (ReLaw) enacted in 2005, brought into force on 1 January 2006, and with amendments effective April 2010. The Central Committee enacted the law with overwhelming support, suggesting that Chinese legislators almost unanimously recognised the need for renewable energy (Wang 2007). The law was drafted over a two-year period, and advice and comments were provided by international and domestic experts, various types of organisations and governmental bodies in order to calibrate it to fit China's ambitions (Anonymous 3 2011 and 4 2011; Martinot and Li 2007). The law was, therefore, the result of an international learning process, in which experiences from abroad were taken into consideration before enactment. This was also the case before each of the major revisions of the ReLaw in 2009 and 2010.

ReLaw measures include government installation goals, mandatory market shares, a tariff system, a cost-sharing principle and a special fund (Jiang 2011: 105). The largest investors in Chinese wind farms are state-owned power generation companies, notably the "big five": Guodian, Huaneng, Datang, Huadian and China Power Investment Group (CPI) (Li et al. 2012). In 2013, these five were the five-largest wind farm developers with a combined share of almost 50 per cent of all projects (WWEA 2014). All utilities with a capacity of more than 5 GW of thermal power electricity generation were mandated by the government, through the 11th Five-Year Plan for Renewable Energy, to install at least 3 per cent non-hydro renewable power as a portion of their total capacity by 2010, and 8 per cent by 2020

(Li et al. 2010: 39). These mandated market shares undoubtedly led to an increase in wind power investments. However, one downside was that the large power utilities only cared to fulfil their installed capacity criteria, and had less of an incentive to focus on the hourly production of electricity, which demanded more resources in terms of operation and maintenance. Furthermore, in accordance with the ReLaw, electric utilities are obligated to purchase all wind power produced, and, with the 2009 amendment of the ReLaw, this obligation applies even when there is insufficient power demand on the grid (Martinot and Li 2010).

Coordination, Fragmentation and Policy Experimentation

Concession Rounds as Policy Experiments

A central point made by Lema and Ruby (2007) is that the period prior to the national wind concession programme, which began in 2002, was dominated by an extensive fragmentation of authority – for instance, in deciding whether to establish a domestic industry or rely on imported turbines. With the concession strategy, however, this fragmentation changed, and the NDRC took a more active role in coordinating the supply of and demand for wind power. Lema and Ruby also note that coordination between the trade and industry departments is what sparked the domestic wind turbine industry. This change in the status of the NDRC was undoubtedly important; however, Lema and Ruby underestimate the importance of the concession projects as an experimental point for policy development. Between 2003 and 2007, there were five concession rounds totalling 2.6 GW of installed wind power capacity, against a total of 6 GW of installed wind power at the end of 2007 (Jiang et al. 2011), amounting to 43 per cent. Each concession round grew in size, starting at 200 megawatts (MW) and ending at 950 MW. Between each of these rounds, policy was changed and refined. For instance, in order to prevent developers from bidding at unacceptably low prices to secure the right to develop a wind farm, the criterion changed in 2005 from "lowest-price bid wins" to various factors outside of price being weighted. Initially, the price was weighted at 40 per; it was further reduced to 25 per cent in 2006 (Li et al. 2007). Other criteria became more important for winning a bid: domestic manufacturing content, overall capability, technical planning, grid price and economic benefit, each having been given a weighted score (Li et al. 2006). The concession rounds

provided important lessons in shaping the pricing mechanisms of the Renewable Energy Law, where "government-guided" prices were decided on the basis of the concession project pricing (Martinot 2010). These prices were, in turn, at the base of the nationwide feed-in tariff prices (implemented in August 2009), and determined prices for four different geographical zones sorted by wind resource quality (Martinot and Li 2010; Wang, Qin and Lewis 2012). As the interviewee from the Global Wind Energy Council pointed out:

> The concessions are only a small share of the whole wind development. The government is using [the concessions] as small projects that demonstrate what the government want the wind industry to be; they want it to be modernised, to be bigger, to rise and lead […] the global trend. (Anonymous 1 2011)

What started as an experimental policy in 2003 was scaled up and laid the basis for both policy learning and further refinements in wind power development up until 2009. The NDRC's coordinating role in the concession projects was important, but the concession rounds in themselves were useful for experimenting and gaining experience with pricing policies, which facilitated the coordination of further wind power projects through the national feed-in tariff. This policy development process therefore conforms to Heilmann's (2008a, 2008b) policy experimentation thesis.

Speedy Approvals

Until 2011, China's wind industry saw a rapid expansion; yet, since 2011, there has been a slowdown. This slowdown is highly relevant for the governance of the wind sector; as coordination premised its rapid development in 2003, it was also coordination that led the expansion to a halt in 2011, by centralising the approval of new wind farms.

Between 2003 and 2011, more than 90 per cent of constructed wind farms in China were approved by local governments – something that led to a mismatch between local wind farms and centrally planned power grid construction (Li et al. 2012). These local governments handled each tender application efficiently, and new projects were rolled out quickly. Included in the aforementioned concession rounds were projects of more than 50 MW, which needed approval from the central government (NDRC). Projects below 50 MW could typically be approved by local governments, and this led to large numbers of projects sized at 49.5 MW, many of which were installed right next to each other, making their real sizes much larger (Jiang 2011). As of 2011, China centralised this decision, and all wind

projects were then required to be approved by the National Energy Administration. This new legislation approved a total of approximately 27 GW for the 12th Five-Year period (up to 2015), 13 GW for state-approved projects and 14 GW for those locally approved (Li et al. 2012). In April 2012, a second group of approved projects totalled 15 GW. Any projects that were not approved through this bill were not accepted (Li et al. 2012). In addition to 18 new technical standards issued in 2011 – limiting access to turbine manufacturers that did not apply to these standards – the change in the approval process considerably altered the growth of new wind farms in China. Thus, decentralisation of authority was beneficial for the speedy growth of China's wind industry, and, by centralising this authority, growth slowed. In other words, fragmentation and centralisation are characteristics the government can draw on to reach development targets.

The reason local governments decided to approve projects so quickly can be attributed to their quest for economic growth. What we observe here is a divergence between provincial and central government interests that characterise Chinese politics. Local governments are increasingly concerned with stimulating local economic growth, and wind power projects were attractive to local economies looking for a boost (Anonymous 7 2011). Although provinces have become more economically independent from the centre (Saich 2011: 183), central government approval also shapes provinces' opinions on profitable investments. As a result, when a company or sector receives central support, they are considered a safer bet for provincial governments seeking to build up an industry. This makes a difference when local governments face the choice of whether to start a wind project or a thermal power project.

Legitimacy and Centralisation

In order for a new industry to come into existence, a certain level of legitimacy is required. In China, important policy measures have been directed at established energy companies that have pre-existing legitimacy. An example of this is the government's introduction of the mandated market share of non-hydro renewable energy for the established power producers in China. This mandate was a clear signal that the road to renewables was to go through the existing power utilities, irrespective of their ties to coal and hydropower. Another strong signal of commitment is provided when areas of priority are decided through long-term plans by central and local governments. The Five-Year Plan is the most important

government document, and the attention given to new and renewable energy has increased over the course of twelve Five-Year Plans, beginning with the sixth and culminating with the latest plan, covering the period of 2011 to 2015 (Yuan and Zuo 2011). Without a doubt, these government indications play an important role in paving the way for emerging industries. This section highlights three more avenues that draw on central government authority and legitimacy in the development of the wind industry.

Control of Media

In the Chinese wind turbine industry, the role of the media is particularly observed in the 2011 downturn. Several informants mentioned that during 2011 stories about quality issues and poorly functioning turbines started appearing in the media. As the Chinese media is largely state-controlled, the CCP can dictate what is allowed to report. This was highlighted by the informant from the Global Wind Energy Council:

> [The government] can one day say that "we think this industry is very promising" and everything [is] good about it; […] everything you can see related to wind in the news is good. This reinforces the industry to expand. Now, this year, it's a time when some of the problems that were hidden started to get exposed […]. Every problem was there two years ago; it's just that people were not allowed to say it, so it didn't seem to be there. But now we are suddenly allowed to say that [there are problems], and people get a feeling that wind started to show its side effects. But that's not true, the side effects have always been there; it's just that they are exposed at this stage. (Anonymous 1 2011)

This quote illuminates the importance of the media in establishing the legitimacy of the wind industry. What we basically observe is a government that uses legitimacy as a tool to increase or decrease interest in the wind industry, fluctuating with current development goals. To be sure, highlighting the challenges that the industry faces regarding turbine quality or grid connection issues is important for the overall performance of the industry. Yet, the fact that these issues were evident for some years prior to 2011 and there had not been any repercussions testifies to the importance of information control in China. This form of legitimation is, therefore, a well-trained muscle of China's institutional body, and its strength ultimately depends on the degree to which the government (the CCP) and industry goals are in sync. This well-trained muscle led to rapid growth in the period until 2011, and when a focus on quality finally emerged it contributed to slowing growth.

Politics over Economics

The Chinese wind industry has gained legitimacy within established institutions by using the pre-existing influence of energy incumbents to shape outcomes. Many of the large, influential state-owned enterprises (SOEs) have engaged in wind turbine manufacturing, and their regional political influence has facilitated their growth. According to the informant from the wind turbine manufacturer XEMC Windpower, subsidiary of the large multi-industry conglomerate Xiangtan Electric Manufacturing Corporation (XEMC), the company "has a certain influence in Hunan Province, because the governor of Hunan Province came from XEMC". As a result of the company's political connections, it has been able to convince policymakers of the benefits of wind turbines. Indeed, there is a well-documented link between SOEs, economic performance and political careers (Andrews-Speed 2011; Li et al. 2008; Xu 2011). This relates to the Ministry of Personnel, which has the capacity to appoint or dismiss the senior executive leadership of even large SOEs. Often, industry professionals are appointed to these positions because of their technical insights, and these positions are, in turn, used as stepping stones for political careers, similar to that of the XEMC executive (Rosen and Houser 2007). This means that the leadership of large energy companies must be attentive to party politics, and balance central political demands against personal ambitions and provincial needs. All large, state-owned energy companies are mandated (through the Renewable Energy Law) to produce electricity from renewable energy sources, and failure to comply can hamper company advancement and political careers. One interviewee put it this way:

> The incentive for the leaders of the power companies to fulfil this requirement is that they will be held accountable if targets are not reached […] and this will directly impact their personal careers. (Anonymous 2 2011)

Moreover, central government support often means more in terms of politics than in terms of economics. This was demonstrated in several interviews – for instance, with XEMC Windpower:

> The company's own investment is larger than government funding, but state funding is also very important to us; it shows that the state encourages [us] to keep up. Especially for our group, a very large SOE with a long history, the state funds mean more [in terms of] encouragement than […] real impact. After the state funding, we have more voice in Hunan Province, which means the Hunan provincial government would be more supportive to us. (Anonymous 5 2011)

A similar line of argumentation was presented by a government official from the Energy Research Institute of the NDRC:

> [The government] has promoted R&D a bit; some national research centres and test centres have been supported by the government. And that has been enough because it proved the legitimacy of the industry. (Anonymous 8 2011)

Central government subsidies and support eliminates some of the risk local governments face in choosing their investment strategies, and it allows large companies to be more confident in entering a new industry such as the wind industry. The central government, therefore, incentivises SOEs to follow its legislation by appealing to a company's success and the benefits to the political careers of managers, and it also makes a company's success more likely by showing its support.

Related Industries

The political power and legitimacy accumulated in other industries has also been marshalled for the wind industry. Most of the large turbine manufacturers in China have parent companies from related industries within machinery and equipment manufacturing, as well as direct links with electric power utilities. A case of the latter is Guodian United Power, a subsidiary of Guodian, which is one of the five state-owned electric power companies (the "big five") and by far China's largest wind power installer (Li et al. 2012). Since Guodian United Power was established in 2007, it has grown to become the third-largest Chinese turbine manufacturer (a milestone reached in 2013) and it is one of the fastest-growing companies in the wind industry (WWEA 2014; Li et al. 2012). The company has benefitted greatly from the unique position of its parent company in wind farm development, which was also emphasised in an interview with the Deputy Director of United Power's Chief Engineering Office, Mr. Xiao Jinsong:

> United Power has the advantage of control throughout the entire supply chain. In addition to providing the complete machine, we also produce major components – blades, gearboxes, generators, pitch systems, inverters, etc. Furthermore, our parent company, Guodian, *is the largest wind power developer in Asia*. (DNV 2011, emphasis added)

The experience of large industrial companies has been crucial for the advancement of many wind turbine manufacturers, many of which have come from the coal power equipment manufacturing industry. The three largest coal power equipment manufacturers, Shanghai Electric Group, Harbin Electric Corporation and Dongfang Electric Corporation, which provide nearly all the advanced coal power equipment in China (Yue 2012), all have subsidiaries in wind turbine manufacturing. For instance, the central government–administered Dongfang Electric, the fourth-largest Chinese wind turbine manufacturer in 2013 (WWEA 2014), has a history of more than fifty years in manufacturing heavy-duty machinery and equipment, such as steam and hydro-turbine generators (DEC 2012). This company, one of the largest steam turbine producers in China, did not engage with the wind industry until 2005, when it started cooperating with European turbine design companies (Zhao, Hu, and Zuo 2009). In addition, Shanghai Electric has signed strategic alliances with the Western firm Siemens. All these companies have become large actors within the Chinese wind industry by exploiting their established legitimacy within China's institutional framework. They have, indeed, taken advantage of their carbon-intense backgrounds to diversify into low-carbon industries.

Discussion

The previous section has shown how the media, local politics and related industries have been drawn on to facilitate development of wind power in China. However, this choice of governance carries with it several "nuisances" that lead to goals being reached only partially or with several consequences. One recurrent topic is the priority of quantity over quality, and policies are often created without any enforcement mechanisms in place. Two major challenges associated with the renewable energy law are 1) the absence of functioning enforcement mechanisms and 2) a lack of clear formulation of responsibilities. These two problems together reduce the commitment of grid companies to acquire wind-generated electricity. For instance, the law requires grid companies to acquire all electricity they produce from renewable energy, but the wording "guaranteed acquisition" is not adequately defined. This leaves room for interpretation, and grid companies end up curtailing wind power without any repercussions (Li et al. 2012). Furthermore, wind power producers are also required to assist grid companies in ensuring power supply safety, which gives grid companies more arguments to curtail wind power when there is oversupply.

One of the drawbacks of the central government's strategic usage of SOEs and established companies is related to the preference of industry creation, and hence quantity before quality. This affects the wind industry through the Chinese banking system, which is government-controlled: In 2009 four major commercial banks accounted for more than 70 per cent of China's financial assets (Walter and Howie 2011). The main task for Chinese banks has largely been to support the SOEs, even after economic reforms of the banking and finance sectors (Walter and Howie 2011). According to Saich (2011), commercial banks are directed to lend to state-owned enterprises, even though three so-called "policy banks", which specifically look after government-mandated lending, were created in 1994. In effect, this means that the banks are instruments that the government can use to achieve development goals. One key measure the government uses to control the market is the deposit reserve ratio (Anonymous 6 2011): the minimum reserve amount each bank must hold of customer deposits. This ratio had been increased several times before 2011, making it more difficult for the banks to lend out money, contributing to the 2011 slowdown of the wind industry.

In order to fully grasp what this means for the wind industry, recall that the largest investors in wind power projects are large energy investment companies owned by the central government. These SOEs obtain loans more easily than private competitors, and this preference for SOEs may, in turn, cause scale advantages, as pointed out by the interviewee (No. 1, Sep. 2011) from GWEC:

> In general […] [the SOEs] will order in large quantities and of course this will give them an advantage in negotiating the component's price, and that of course will get the price down. (Anonymous 1 2011)

Even though the support of large SOEs has created rapid growth thus far, their preference could lead to a lack of project evaluation behind credit decisions. This concern was expressed by an experienced wind energy consultant in China, who commented:

> The government approves the projects and the money is going to state-owned companies, so within the state sector there is no major perception of risk. On the one hand, there is no technical and commercial diligence, or specifically what we would call "project finance" behind most wind farms. But on the other hand, when the signal is alright, every loan officer or every bank knows it's not a bad idea to lend money to wind projects, and that has enabled the wind industry to flourish. (Anonymous 7 2011)

We thus see that the preference for low-quality, state-owned projects, induced by government investment, is potentially destructive. The strategy of supporting SOEs will likely continue, although the slowdown since 2011 has impacted these companies.

As Table 1 shows, there are both drawbacks to and benefits from fragmentation and centralisation. The successful orchestration of both these characteristics of China's policy governance is what determines the final outcome.

Table 1: Impacts of Fragmentation and Centralisation

	Benefit	Disadvantage
Fragmentation	Rapid growth	Low grid connection
Centralisation	Legitimacy	Quality

Source: Author's own compilation.

Garcia argues that gradualism, consisting of experimental and incremental policymaking, creates barriers in China such as "legal insecurity, fragmentation of bureaucracy[,] targets that remain non-binding" (Garcia 2011: 8048), and so on. This paper has shown that gradualism and fragmentation are not entirely negative: Experimentation has paved the way for new policies, contributing to a quality-check of policies with a smaller impact area, which have then been scaled up. The concession rounds amounted to 43 per cent of the total installed wind power capacity by the end of the last centrally given concession, meaning that they were not the largest source of turbine installations at that point. However, the concession rounds predated the Renewable Energy Law and provided useful experience for fine-tuning the legislative measures.

The policy choice has not been innovative. In fact, successful wind policies have tended to be very similar, globally (Lewis and Wiser 2007). But the way policy has been implemented – by combining experiments, which are then scaled up, with a fluctuation of central government involvement in the industry – has proved effective. Fragmented authority in China's policymaking system has been conducive to implementing renewable power sources, as shown in the example of speedy approvals of wind farms. Local governments conducted these approvals, and when misalignments occurred between central and provincial government development goals, centralisation of decision-making slowed development. At the same time, the experimental basis of policy development has gradually developed a larger framework for domestic and foreign wind industry actors in China. We

can therefore say that this alternation between centralisation and fragmentation is similar to Cunningham's (2009) "portfolio approach" thesis.

Drawing together the insights on experimentation and the "portfolio approach", we see that the Chinese institutional framework is able to draw from established actors and networks, as well as to create avenues for new ventures. These avenues often take the shape of experimentation with policies which are later scaled up. Fragmentation pervades China's governing institutions, yet at the very apex, the CCP, by means of steering and guiding, shapes the direction and pace of new industry developments. These various processes behind change and inertia appear in Figure 1.

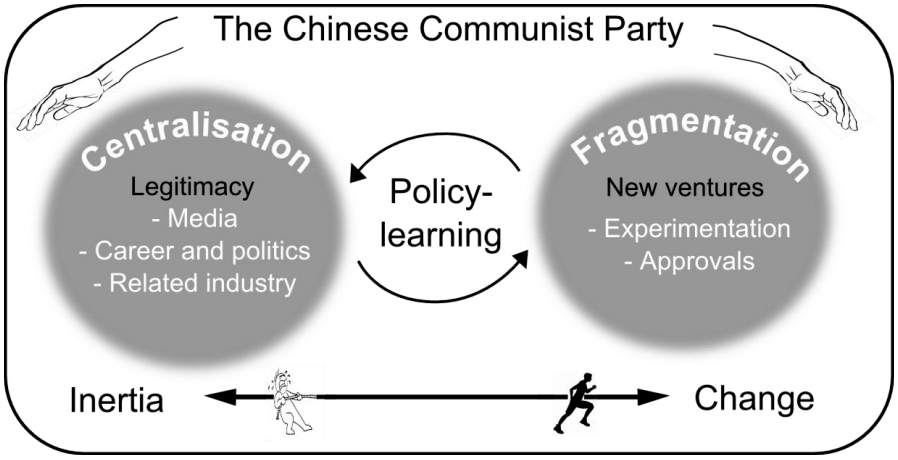

Figure 1: Processes behind Change and Inertia in China's Wind Industry
Source: Author's own compilation.

Some impulses emanate from fragmentation and help induce change, and some originate from centralisation, drawing on hierarchy and accumulated status. The legitimacy held by state-owned enterprises, the invaluable experience accumulated in established firms, and the alluring prospects of political careers are all contingent on pre-existing authority. These processes are more inert and are capable of constraining as much as aiding change.

Conclusions

Surrounded by a dominating coal power industry, a wind power industry has grown in record time over the past ten years in China and the country has mustered an impressive

ingenuity in fine-tuning policy mechanisms to induce the growth a new industry. To be sure, the industry is facing considerable challenges; a quick industry build-up comes with a price. This paper has tried to understand what mechanisms have allowed for the rapid growth of China's apart from the laws and regulations. The paper started out by describing the relevant policies for the wind industry development, then it showed how policy experimentation and speedy approvals were useful for the rapid wind farm expansion. Later sections clarified how the media, legitimacy and experience of existing and related industries sustained central government decisions. I argue that the Chinese government's navigational skills of growing a domestic wind industry are remarkable and that this feat must be understood in a larger institutional picture.

Fragmentation in China's energy governance has allowed for a fast-growing wind turbine market. In times when industry development was sorely needed in order to create domestic wind turbine manufacturers, local governments were allowed to approve wind farm projects, and the media and other actors focused solely on non-critical issues with development. In times of overcapacity, the tune changed radically. This was especially evident after 2011, when the full force of centralising power was levied onto the industry and the wind industry growth rate declined. The government is indeed flexing all the muscles in its institutional body in order to navigate the development.

The institutional traits inducing the rapid growth of China's wind power industry are based on legitimacy, alignment of expectations, and visions of incumbent and upcoming actors. China has managed to leverage space for wind energy, and the processes behind the change from fragmentation to alignment have been dominated by considerable policy flexibility. In practice, the government has induced policy experiments, which have set in motion some of the large state-owned enterprises (SOEs). These, in turn, have had an influence both locally and nationally, and have lobbied towards increased policy support for wind energy. We can therefore conclude that the CCP takes strategic advantage of fragmentation and coordination to steer the pace of development in the wind industry.

These conclusions have implications for other industries as well. The offshore wind industry in China is currently experiencing a similar stalemate to that faced by the onshore industry in 2006, and we can expect developments as soon as interests between the different, relevant authorities have been aligned. Furthermore, China's quest for rapid growth has come at the expense of a concern for high-quality products. For instance, the development goals set by

the government have consistently been measured in terms of installed capacity, and not in terms of total electricity generated and delivered to the grid. A lack of incentive to ensure long-term electricity generation permeates the whole industry chain from component suppliers to local governments approving wind farms, SOEs investing in the wind farms and grid utilities managing the wind farms. This lack of quality control is inherent in Chinese institutions, and it will likely remain a concern for Chinese companies seeking to export their products (Gosens and Lu 2013, 2014). Future research should be directed at determining exactly how these institutional traits influence current industry development in China, and if there is a necessary trade-off between rapid catch-up and sufficient quality control.

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Appendix: List of Interviewees

No.	Company / Organisation	Date	Background of interviewee	Affiliation
1	Global Wind Energy Council (GWEC)	Sep. 2011	China Director	Policy/ Research
2	Hanergy Holding Group Limited (wind power developer)	Sep. 2011	Representative	Industry
3	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	Sep. 2011	Project Manager, Renewable Energy Programme	Policy/ Research
4	Chinese Renewable Energy Industry Association (CREIA)	Sep. 2011	Vice–Secretary-General	Policy/ Research
5	Energy Research Institute (ERI) of the National Development and Reform Commission (NDRC).	Sep. 2011	Deputy Director-General	Government/ Policy
6	XEMC Windpower	Oct. 2011	Key Account Manager	Industry
7	China Creative Wind Energy Co. Ltd.	Oct. 2011	Sales Manager	Industry
8	Bloomberg New Energy Finance (BNEF)	Nov. 2011	Wind Analyst	Policy/ Research
9	Nordex China	Nov. 2011	Marketing Manager	Industry
10	Azure International	Nov. 2011	China Wind Expert, Director Research and Advisory	Policy/ Research
11	Energy Research Institute (ERI) of the National Development and Reform Commission (NDRC)	Nov. 2011	Research Associate on Economy and Energy Policy	Government/ Policy
12	Goldwind Science and Technology Co.	Nov. 2011	Technical Support Engineer	Industry

Paper 2: Limits to Interactive Learning: Ensuring Quality in China's Emerging Offshore Wind Industry

Marius Korsnes

Paper accepted (minor revision) and forthcoming in *International Journal of Technological Learning, Innovation and Development,* with new title: 'A sustainable Chinese catch-up? Product quality and interactive learning in the offshore wind industry'. The following version is the original manuscript that was submitted.

Abstract:

Periods of lower product quality appear to be a necessary and accepted part of technological catch-up processes. However, at some point, quality considerations become important. As transitions towards renewable energy only become achievable when renewable technologies actually work, this paper aims at understanding the practices that complicate quality assurance in China's offshore wind industry's attempts to catch up. The paper gives an overview of offshore wind industry actors in China and details technology sourcing strategies and ownership status. Issues related to time pressure and cost savings were anticipated as important reasons for the lack of attention to product quality. More surprisingly, the paper finds that feedback practices between suppliers and manufacturers were unhelpful in ensuring product quality. This was particularly the case in two instances: when ties between the supplier and purchaser were too close (as was true for companies in the same industry group) and when ties were too shallow (as when manufacturers 'shopped' for components, or when suppliers did not care about feedback from manufacturers). Chinese firms will likely continue to struggle to catch up until such relationships are changed and catered for.

Keywords: Interactive learning, catch-up, China, offshore wind turbine industry, quality

1. Introduction

As soon as a product is 'made in China', product quality appears to become a concern. We have all heard of or experienced toys that have fallen apart or cheap tools that have broken. A transition towards more renewable energy in China will not be achievable if new renewable energy technologies intended to last for 25 years fail after only a few years. As China is now investing in offshore wind energy technologies, quality is imperative in order to ensure the sustainability of development. In this paper, 'quality' is taken to mean conformity to established standards. If product quality is compromised to a large enough extent, resources are wasted and renewable energy development may, in the worst case, end up having an altogether negative impact on the environment. This paper therefore investigates the role of quality in China's efforts to catch up with Europe in offshore wind technology, and provides a novel perspective on how latecomer firms in an emerging industry approach technological capabilities and learning.

Offshore wind is an emerging global industry that is most highly developed in the North Sea. At the end of 2014, Europe had more than 8,000 megawatts (MW) of installed offshore wind power, compared to about 670 MW in China (GWEC, 2015; EWEA, 2015). Since the Chinese offshore wind industry is in its early phase of development, there is considerable uncertainty about its development and direction. Recent literature on China's onshore wind industry has found that Chinese turbine manufacturers have all largely developed their own design capabilities, predominately through cooperation with foreign actors (Ru et al., 2012; Silva & Klagge, 2013; Gosens & Lu, 2013; Lema et al., 2013; Lewis, 2013; Y. Chen et al., 2014). There is, however, an established consensus that Chinese turbines perform slightly worse than their European counterparts (Steinfeld & Beltoft, 2014; Kirkegaard, 2015), and that Chinese product quality has been neglected (Gosens & Lu, 2014; Lewis, 2013; Korsnes, 2012; Walz & Delgado, 2012; He & Chen, 2009). Can we expect the same of China's offshore wind industry development?

Many question whether China will be able to innovate, or whether it will remain 'stuck in commodity manufacturing, undifferentiated activities for which innovation is absent' (Steinfeld, 2004). This debate is coloured by believers and doubters, and its conclusions appear to hinge on the definition of innovation employed (Steinfeld, 2010). Believers see new initiatives in China – such as Taobao and WeChat – as indicators of innovation (Rein, 2014), whilst doubters interpret them as mere copies of Western innovations (Dodson,

2012). Although this paper will not provide an answer to this debate, it will shed further light on the more detailed learning processes that occur when a new technology is built. The paper focusses on technological learning with an emphasis on practices that promote or hamper product quality.

Discussions of technology transfer and catch-up typically revolve around tensions between 'receivers' and 'providers', and whether transferred technology has been adopted to such an extent that the technology is mastered – meaning that the 'receiver' can innovate independently from foreign assistance and contribute to global technology development (Kim, 1997; Ernst & Kim, 2002; Lewis, 2007). Here, technological catch-up is a strategic *ambition* for latecomer firms, whilst the *process* of catching up is dependent on technological learning and the development of technological capabilities within latecomer firms. The process of catching up can be described as a process of reaching an established world standard, in terms of product performance (Kumaraswamy et al., 2012). An important but somewhat neglected aspect of technology mastery is the production of goods that are of acceptable quality. Studies of quality and supply chain management in China tend to be limited to international supply chains, focussing on Chinese suppliers' failure to accord to the requirements and procedures of international buyers (Roth et al., 2008; C. Chen et al., 2014; Midler, 2007; Harris, 2009). In these studies, Chinese suppliers are typically perceived to fail due to deficits in regulation, inspection, testing, monitoring or control (ibid.). By understanding product quality as inherent to interactive learning processes, this paper takes another starting point. In this paper, the interaction between Chinese manufacturers and domestic and foreign suppliers is taken to reveal how successfully the firms consider quality and, ultimately, innovate.

Product quality is an elusive topic, as quality is a matter of definition. For instance, if a product is sufficiently cheap, a consumer may opt for it regardless of quality (Wan et al., 2015). In fact, there is no consensus on the definition of quality (Yong & Wilkinson, 2002; Reeves & Bednar, 1994). Quality therefore changes according to the need and criteria at hand, and it can be difficut to measure (Garvin, 1984; Sousa & Voss, 2002). A customer, a manufacturer and a supplier may have different expectations of product quality (Gehani, 1993). An increasingly popular way of evaluating quality is measuring conformity to an established standard – one that has typically developed in the most advanced companies (Busch, 2011; Garvin, 1984). Indeed, some scholars have noted that quality has moved from

being a concept that mainly occupies engineers to a field reserved for managers (Power, 1997). Quality, seen this way, is the result of a process that renders quality measurable, even in cases where it is difficult to measure, so it can be audited by a third party. Power (1997, p.60) therefore concludes that 'there is no quality without quality *assurance*', implying that quality is a form of impression management. In other words, as long as a product conforms to criteria set by someone (e.g. developed countries), it is of good quality. In this paper, I take this working definition as a point of departure and ask whether such product quality criteria set the bar for companies in China, or whether Chinese industry actors understand quality differently. What does product quality mean in a catch-up setting? Lastly, what procedures facilitate or complicate product quality considerations in China's offshore wind industry?

The paper proceeds as follows: Section 2 outlines the theoretical approach, focussing on catch-up, learning and technological capabilities, before section 3 explains the methods used to collect and analyse data. Section 4 gives an overview of the main actors in China's offshore wind industry and summarises their ownership and technology acquisition strategies. Section 5 points to the main challenges in ensuring product quality, and section 6 goes into more detail by examining the relationships between suppliers and customers. Section 7 discusses what product quality means in a setting of catch-up and technological learning, and provides concluding remarks.

2. Interactive learning, technological capabilities and quality

The offshore wind industry in Europe is relatively mature, and the emergence of offshore wind technology in China can be understood through analytical lenses that emphasise the learning and interaction that occurs between these regional industries. A variety of theoretical approaches can be used to understand the way in which interactions between frontier and latecomer firms produce learning opportunities in catching-up countries. These approaches, which range from national innovation systems (Lundvall, 2007; Nelson, 2007) to leapfrogging (Lee & Lim, 2001), catch-up (Kim, 1997), global production networks (Ernst & Kim, 2002) and global value chains (Humphrey & Schmitz, 2000), attempt to capture the internationalisation of innovation processes. Further, each approach recognises the interaction between leading and latecomer firms, and the effects of this interaction on

both parties. In a globalised economy, we may therefore talk about reflexive learning processes that engender new opportunities for both international and local actors (Hansen, 2009b). In the following, we shall look closer at technological capabilities and learning in latecomer firms in China.

The literature on late industrialisation, catch-up and latecomer firms (Amsden, 1989; Lee & Lim, 2001; Mathews, 2002) grapples with the processes undergone by latecomer firms to acquire the technological capabilities of frontier firms, usually based in more industrially advanced countries. Technological capability is taken to be the 'ability to use technological knowledge efficiently to assimilate, use, adapt and change existing technologies; and to create new technologies, developing new products and processes' (Xiao et al., 2013, p.2). Typical successful catch-up cases include the Korean chaebols (i.e. Samsung, Hyundai and Daewoo), which Kim (1997) describes as having undergone a catch-up process from imitation to innovation. The chaebols, enjoying considerable domestic government support, were able to go from mere manufacturing of frontier firms' products to reverse engineering and eventually design and production of those products. In the process, the chaebols hired foreign consultants, educated people abroad, invested heavily in research and development (R&D) and even set up R&D centres in the most advanced industry-clusters (ibid.).

Kim (1997) identifies four technology transfer mechanisms latecomer companies use to acquire technology from foreign frontier companies. These mechanisms are here referred to as 'learning mechanisms', rather than technology transfer mechanisms, as learning puts the impetus on the 'sourcing' process, rather than the 'transfer' process of technology development (Ernst & Naughton, 2012). Two learning mechanisms relate to whether the latecomer company is actively (e.g. licensing) or passively (e.g. importing machinery) seeking the technology. The two other mechanisms relate to whether learning happens through market mechanisms (e.g. trade or technology licensing) or more informally, such as through technical assistance from abroad (active) or reverse engineering (passive) (Kim, 1997). These mechanisms appear in Figure 1, below.

	Active	Passive
Market mediated	Formal mechanisms (1) (Foreign direct investment, licensing, turn-key plants, consultancies)	Formal mechanisms (2) (Commodity trade, standard machinery transfer)
Non-market mediated	Informal mechanisms (3) (Technical assistance of foreign buyer or vendor)	Informal mechanisms (4) (Reverse engineering, trade journals, observation, etc.)

Figure 1: Technological learning in catch-up

Source: Adapted from Kim (1997).

It is widely accepted that, in order to acquire technological capability, firms need to develop both tacit and explicit knowledge (Gorman, 2002; Ernst & Kim, 2002; Amsden, 1989). Jensen et al. (2007) use the concepts STI (science, technology and innovation) and DUI (doing, using and interacting) to distinguish different modes of learning. The challenge is not to choose between one or the other, but to combine practical, experience-based (DUI) and scientific research-based (STI) modes of learning, as they are fit to acquire different types of knowledge (Lundvall & Johnson, 1994). The DUI mode typically produces tacit knowledge – 'know-who' and 'know-how' – while STI gives priority to explicit knowledge – 'know-what' (facts) and 'know-why'. In this paper, learning mechanisms will be part of a wider definition of innovation, wherein interactive learning and collective entrepreneurship are crucial components (Lundvall, 1988), including both experience-based and science-based learning. With this definition, close and persistent contact between users and producers is central to innovation, since a company cannot be expected to have all required knowledge and skills in-house (Kamp et al., 2004; Lundvall, 2010). Communication, interaction and proximity between users and producers are therefore important indicators of the interaction that occurs in the learning process (ibid.). In the context of China's offshore wind industry, insight into learning modes is important in order to emphasise that latecomer firms must engage with both R&D (science-based learning) and trial and error (experience-based learning) in order to catch up.

Technological learning can nevertheless be hampered by several factors related to the institutions and context in question. Several examples of catch-up focussing on China testify

to this (Altenburg et al., 2008; Xue & Liang, 2010; Mu & Lee, 2005; Gu & Lundvall, 2006a; Gallagher, 2006; Guerin, 2001; Binz et al., 2012). These contributions show that there is a great divergence in successful catch-up strategies depending on the industry, the gap between leader and latecomer firm, the level of technological sophistication (high-tech, low-tech), the level and type of commitment from the government and the intellectual property rights protection. For instance, Wang (2006, p.398) proposes that due to institutional constraints such as 'the state's pro-SOE (state-owned enterprise) industrial policy, the state-owned but also local government-controlled financial system and the fragmented industrial structure', Chinese IT firms were unable to develop internal dynamics that facilitated learning and innovation. Similarly, Steinfeld (2004) claims that 'the innovative capacity of Chinese firms and the ability of those firms to upgrade within global supply chains have been impeded by legacies of Chinese reform style, bottlenecks in the institutional reform process, and most recently—of greatest concern for the future—inconsistencies in governmental industrial policy'. So how can we determine a successful catch-up strategy that promotes the 'innovative capacity' of Chinese firms?

Lee and Lim (2001) note that there is an important difference in catching up in market share, wherein technology is mainly imported, and in technological capability. Clearly, catching up in technological capability is preferred, as it implies larger ownership of and revenue from the technology. We can also distinguish between different types of capabilities. Cai and Tylecote (2008) divide technological capabilities into those that are 'static' and those that are 'dynamic'. Static capability is the ability to use existing technologies to manufacture a product, whilst dynamic capability involves the adaptation of technologies and procedures into a larger learning and development process. Static capability is typically acquired when a frontier firm has a joint venture with a domestic firm, and in effect manufactures the product locally without much interaction and local learning. This was, for instance, the case with Shanghai Automobiles, who had a joint venture with Volkswagen, but no domestic car company emerged as a result of the cooperation, entirely contrary to the Korean catch-up experience (Liu & Tylecote, 2009). Dynamic capability is acquired through a combination of strategies that aim at being independent from foreign companies, and try to learn through both hands-on experience and R&D. Although the acquisition of dynamic capability is considerably more challenging and risky, we can expect it to be integral to a successful catch-up.

Some research has found that the Chinese institutional set-up favours *static* technological capability. According to Xiao et al. (2013), Chinese state-owned enterprises (SOEs) have strong incentives to favour quick increases in revenue and 'shiny new products and factories', typically provided by joint ventures with foreign companies. One reason for this urgency for quick results resides in the government's SOE policy of rotating top-managers every few years, making short-term revenue more important for each manager's career (Shi et al., 2014). Hence, companies that do not have a majority ownership from the central government, or 'outsider' firms that are not favoured by the central administration, are more likely to practice dynamic capability (Cai & Tylecote, 2008; Xiao et al., 2013). These companies, in turn, face tough competition with companies with high static capability, and have a less certain source of financing than do centrally supported firms (ibid.). Therefore, as we go on to the next section, we may expect Chinese firms to successfully catch up with foreign frontier firms by avoiding too heavy a reliance on quick revenue and by ensuring financing opportunities for their investments. In this sense, company ownership may be telling of how successfully companies acquire dynamic capability.

It goes without saying that a successful catch-up in dynamic technological capability also involves an acceptable level of product quality. Knowing that institutions may hinder the ability of Chinese companies to catch up successfully, we may also ask what procedures ensure product quality in China. The difference between static and dynamic capability has implications for product quality. Apart from generating quick revenues for domestic SOEs, joint ventures that generate static capability also have established and accepted criteria for product quality. In some industries (e.g. the automobile, shipbuilding and machine tool industries in Korea), latecomer firms have endured longer periods of sales when their products have been lower quality than frontier firm products (Amsden, 1989; Lee & Lim, 2001). For this reason, a protected domestic market is useful in the early phases of catch-up (Kim, 1997). A latecomer firm must therefore strike a balance between 'accepted' levels of quality and the number of potential buyers, since customers will hesitate to accept lower quality if there is a frontier-firm product, as is often the case in China (Xiao et al., 2013). An example of the latter situation is the continued popularity of the iPhone in China, although local brand smartphones with more competitive prices also exist and capture an increasing market share (Jones, 2014; Flannery, 2014).

Including this point about quality conformity, we can summarise the differences between dynamic and static capability with respect to: 1) the time they require, 2) short-term revenue prospects and 3) conformity to established quality criteria. Compared to static capability, dynamic capability takes more time, has a lower short-term revenue prospect and conforms less to established standards. Hence, we may expect these three considerations to influence the strategies chosen by Chinese firms to acquire technological capability. With this hypothesis as a basis, I will proceed to analyse the learning strategies of firms in China's emerging offshore wind industry.

3. Method

Many studies of China are based on quantitative data, which are useful in understanding the scale and scope of an emerging industry. This paper is based on qualitative data gathered during an 11-month period of fieldwork in Shanghai, including two months of participant observation with a European firm seeking to enter the offshore wind industry and 43 in-depth interviews with a total of 56 interviewees from China's emerging offshore wind industry. Most interviews were conducted in Beijing and Shanghai, but several were held in smaller cities along China's coastline, such as Guangzhou, Hangzhou and Nanjing. Information was also collected through participation and observation at the China Wind Power 2011 and 2013 conferences, the Offshore Wind China 2012 and 2013 conferences and the 8th China (Shanghai) International Wind Energy Exhibition and Conference, as well as several workshops on offshore wind, at which I spoke with experts and professionals in the offshore wind industry in China. The interviews focussed on participants' perspectives on offshore wind, challenges – such as quality or management issues – and differences between onshore and offshore wind turbine manufacturing.

Below is an overview of the interviewees and their respective stakeholder segments in China's offshore wind industry. The relevant stakeholders are divided into six groups: government, turbine manufacturers, turbine supply chain, 'offshore suppliers', developers and research community. Government stakeholders consisted of officials in local, provincial and central government agencies, including several state-administered industry associations. 'Turbine supply chain' refers to all the components needed to assemble a wind turbine, and 'offshore suppliers' here means all the equipment and services for an offshore wind farm (including the electricity grid), excluding the wind turbines. For the following analysis,

insights from the turbine manufacturers, turbine supply chain, offshore suppliers and offshore wind project developers were the most relevant, as these persons made key decisions in terms of investment, quality control, time-usage and so on. Nevertheless, feedback from all industry segments informed the analysis.

Table 1: Overview of interviewees

Industry segment	**Interviews**	**Number and nationality of interviewees**		
		Chinese	Foreign	Total
Government	**8**	**11**	**1**	**12**
Turbine manufacturer	**7**	**8**	**1**	**9**
Turbine supply chain				
- Gearbox	1	1	0	1
- Pitch and yaw system	1	1	0	1
- Control systems	1	0	1	1
Offshore suppliers				
- Advisory	6	4	3	7
- Certification	6	3	1	4
- Forecasting	1	2	0	2
- Grid	1	1	0	1
- Coating	3	3	0	3
- Cable	1	3	0	3
- Installation and foundation	1	1	0	1
Project developer	**5**	**9**	**0**	**9**
Research	**1**	**2**	**0**	**2**
Total	**43**	**49**	**7**	**56**

The interview data were analysed according to principles suggested by 'abductive reasoning', meaning that both field data and existing theory were allowed to influence the researcher, but, ultimately, instead of forcing either the theory or the data into a framework, the researcher left space for his own logical reasoning (Reichertz 2007). The analysis is also inspired by constructivist grounded theory (Charmaz, 2006; Clarke, 2005). Thus, analysis started at the data collection stage, and interview structures changed as I developed a better idea of the topics I wished to pursue in more depth. This enabled a greater focus on topics of interest throughout data collection, and it made coding easier, as all the data had been gathered. The data were analysed and coded using the computer assisted analysis tool NVIVO. Coding took place after all the interview material had been gathered, and before much theoretical search had begun. In this way, the analysis of the data was guided by existing theories and was based on grounded concepts.

4. China's offshore wind industry stakeholders and learning opportunities

This section examines the main stakeholders in China's offshore wind industry, namely the turbine manufacturers, component suppliers and offshore suppliers. Knowing that onshore wind energy companies were the primary drivers behind Germany's offshore wind energy industry (Fornahl et al., 2012), we start by looking at the onshore wind companies' diversification into offshore wind in China. Currently, ten companies have produced operational offshore wind turbines. From Table 2, we see that Sinovel has the most models in operation, and three other companies have two turbine models in operation. In China, there are 117 centrally administered state-owned enterprises (SOEs) that control assets totalling 60 per cent of China's gross domestic product (Bound et al., 2013), testifying to the immense importance of SOEs to the Chinese economy. In the table, 'central SOE' refers to whether the company in question is part of centrally administered SOEs, which are administered by the State Asset Supervision and Administration Commission (SASAC). 'SOE' refers to a state-owned enterprise that is not directly administered by SASAC.

Table 2: Chinese offshore wind turbine designs, technology sourcing and affiliation

Company	Turbine size (MW)	Technology acquisition	Ownership	Parent company's main industry
Sinovel	3, 5, 6	Joint design, AMSC-Windtec (3MW) Own design (5 and 6MW)	SOE	Heavy machinery
Goldwind	2.5 / 6	Own design, Vensys	SOE	Wind
CSIC Haizhuang	5	Joint design, Mecal	Central-SOE	Shipbuilding
Mingyang	2.5	Joint design, Aerodyn	Private	Power generation equipment
Guodian United	5 / 6	Own design	Central SOE	Power generation / developer
Shanghai Electric	3.6	Joint design, Aerodyn	SOE	Power generation equipment
Dongfang	2.5 / 5.5	Joint design, AMSC-Windtec	Central SOE	Power generation equipment

XEMC Wind	5	Own design, Darwind	SOE	Heavy machinery
Envision	1.5	Own design	Private	Wind
SANY	2	Joint design, Sheyang University of Technology	SOE	Heavy machinery

Sources: Interviews, company webpages, BTM (2012), Gosens and Lu (2014).

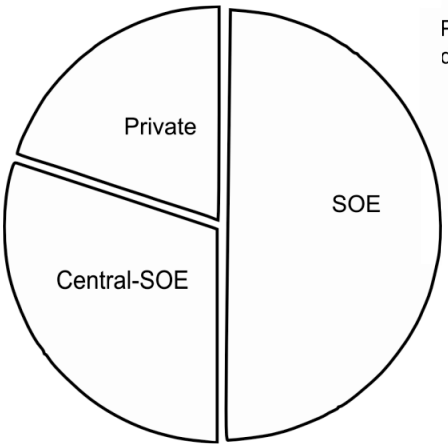

Figure 2: Ownership of offshore wind turbine companies

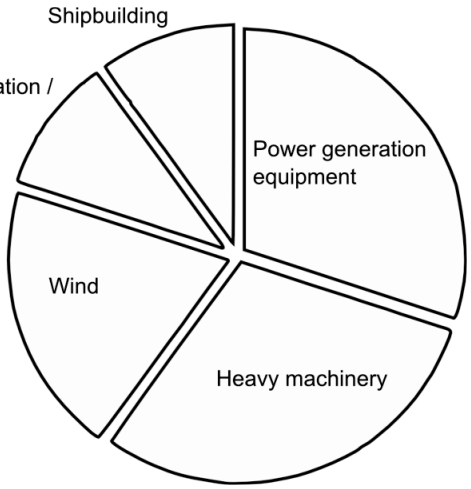

Figure 3: Main industry of offshore wind turbine companies

Three of the companies listed above are part of centrally-owned SOEs, and five are part of SOEs. Only two of the companies, Mingyang and Envision, are privately-owned. In terms of main industry, only two companies, Goldwind and Envision, are purely wind power manufacturers. Sinovel, Shanghai Electric, Dongfang, XEMC Wind, SANY and Mingyang are subsidiaries of large industry groups that have their main industries within power generation equipment or heavy machinery. United Power is a subsidiary of the largest power generation company and developer, Guodian (mother company of Longyuan), and the last company, CSIC-Haizhuang, is a subsidiary of the large shipbuilding group China Shipbuilding Industry Corporation, a group that also produces gearboxes and other key wind turbine components. In terms of technology acquisition, five of the companies have their own designs tested for offshore turbines, whilst the five others jointly design their turbines with foreign (Mecal, Aerodyn and AMSC-Windtec) and domestic (Sheyang University of Technology) collaborators. The process Chinese wind turbine firms went through to acquire

these technologies has already been extensively elaborated on by others (e.g. Korsnes, 2012; Lewis, 2013; Gosens & Lu, 2013, 2014; Chen et al., 2014), and we shall not look closely at those strategies here. Rather, we shall examine the supply chain, including what is here termed 'offshore suppliers'.

Looking at the wind turbine supply chain, suppliers of onshore wind turbine components in China typically also supply components for offshore turbines. China's component supply for onshore turbines has a shared supply-base of components, allowing for industrialisation, quick manufacturing and economies of scale (Lema et al., 2013). There are more than 50 blade manufacturers, 100 tower manufacturers and 1000 manufacturers producing other components and parts for the onshore wind industry in China (Kastmann, 2013). In the offshore turbine supply chain in China, many companies increasingly choose to source their components from abroad. For instance, Goldwind decided to increase international component sourcing for their offshore wind turbines to approximately 50 per cent of its needs (Quartz+Co, 2013). Several of the interviewees from large wind turbine manufacturers confirmed this trend for their offshore turbines. This increase in the import of turbine parts can be interpreted as a confirmation that the quality of domestic components is not adequate, and that the European standard is considered the relevant benchmark. I will return to this issue in section 6.

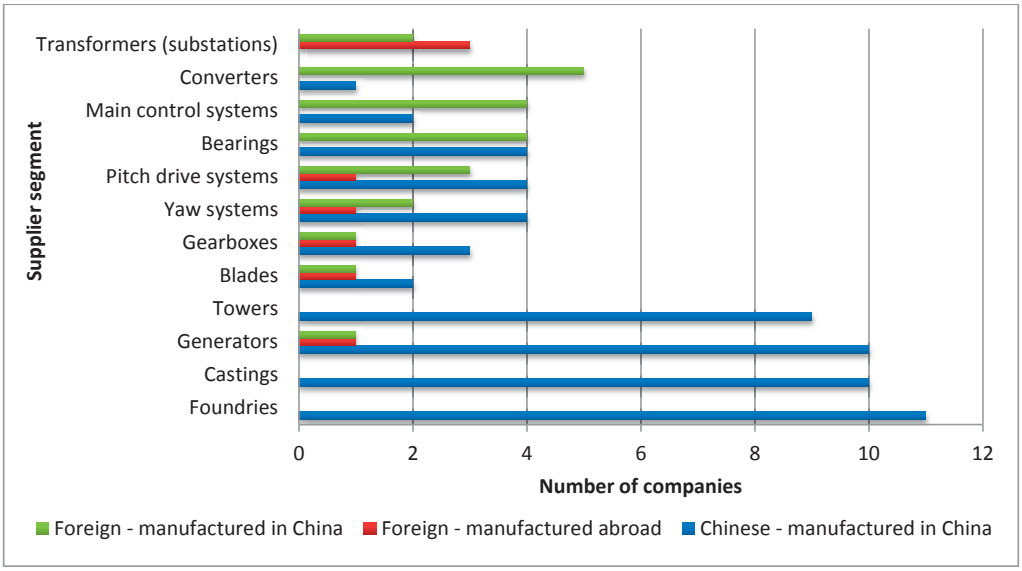

Figure 4: Overview of domestic and foreign suppliers for Chinese offshore wind turbines

Source: BTM (2012), company webpages.

Figure 4 shows the domestic and foreign suppliers for Chinese offshore wind turbines. Until the end of 2012, the total number of suppliers for Chinese offshore wind turbines was 91, indicating that the offshore wind turbine supply chain is quite wide. The figure shows that high-tech and high-precision components such as transformers, converters, control systems and bearings are typically sourced from foreign companies, whilst domestic Chinese companies supply components at the low-value end, such as towers, castings and foundries. The competition in these low-value segments is higher than in the other segments, having on average ten or more suppliers, as opposed to only four blade suppliers (two domestic and two foreign) for Chinese offshore wind turbines. This is consistent with research pointing out that China has thus far been unsuccessful in acquiring high-value technology (Tylecote et al., 2010; Moran, 2011; Gu & Lundvall, 2006b).

If we consider the total cost of an offshore turbine, BTM (2012) calculations show that towers, blades and gearboxes are the most expensive, and make up about 56 per cent of the capital cost. Apart from the towers, which are entirely dominated by Chinese suppliers, there are no clear tendencies as to who typically supplies these more expensive components for Chinese offshore wind turbines. The majority of foreign suppliers actually manufacture their components within China, enabling similar procedures of quality control as those used

abroad. The presence of foreign suppliers may, on the one hand, mean that management procedures are also transmitted to Chinese suppliers through informal mechanisms, but it may also mean that knowledge still rests in foreign hands.

In the 'offshore suppliers' segment, the most important players participating in offshore wind projects to the end of 2013 appear in the appendix. Large SOEs often enter and invest in new industries in China, with varying degrees of success in terms of acquiring technological competence (Liu and Tylecote, 2009). Ten out of the 17 companies are listed as one of the 117 central SOEs, testifying to the importance of centrally governed SOEs in this segment. Most of the actors in the offshore segment have a background in the oil and gas, maritime and shipbuilding industries. Today, China is amongst the top shipbuilding nations in the world; there are several ship industry clusters, especially in Jiangsu province (Chen, 2014; Zheng et al., 2013), and China's oil and gas companies are amongst the largest in the world (Bound et al., 2013; Andrews-Speed, 2012).

Shanghai Zhenhua Heavy Industries (ZPMC), for example, grew large based on crane production; the company increasingly produced more components in-house, and expanded into new industries (Plötner & Wang, 2013). In the early phases of China's offshore wind development, their cranes – designed for use on offshore oil and gas structures – were used for installing turbines (BTM, 2012). Moreover, several vessels for offshore wind turbine installation are produced in China, and this can be beneficial for the domestic offshore wind industry. However, when it comes to coating and offshore sub-stations (traditionally an offshore oil and gas business), foreign companies dominate the market. With this overview of the main stakeholders in China's offshore wind industry, we now proceed to examine some of the challenges, considerations and procedures for ensuring quality.

5. Time, skill and conformity

Amongst the offshore wind industry stakeholders, the general attitude was that product quality was lower in China. For example, a Chinese employee in a European certification company said that: '[Quality] is a normal problem in China. If the quality were the same as European products, then why can't we sell our turbines to you?' This understanding of European products having superior quality was prominent in the data, and we may therefore broadly say that the European standard was seen as the quality benchmark for Chinese firms.

One way of ensuring that a product conforms to an established standard, and hence reaches accepted quality levels, is to certify the technology. In the list of certifications from a large international certification company, DNV GL (2014), are six Chinese wind turbine manufacturers with type certificates and 12 with design assessments. A type certificate is a certificate for a specific turbine design, and a design assessment (or evaluation) is necessary for a full certificate, but lacks certain important stages related to testing and manufacturing. Both turbine and component manufacturers agreed on the importance of certifying their products. Indeed, some manufacturers viewed an international certificate as true proof of technology mastery, as reported by an interviewee from China General Certification:

> Certification is taken as a symbol that one manufacturer has established their own capability for the design of a wind turbine. It's a kind of symbol, so in the early stage people are following the certification process to acquire knowledge. The kind of knowledge or the know-how of what the procedure should be, what it looks like and to educate their people of what kind of procedure they have to follow.

As the interviewee pointed out, certification procedures also enabled learning through understanding and striving to reach the standards set by frontier firms. However, Chinese manufacturers' main resistance to certificates and design assessments was that they considerably slowed the product commercialisation plan. Since domestic customers did not require certification in the early phases of the onshore wind industry, certification was not regarded as worth the extra time. Getting products quickly to market was considered more important than going through the necessary testing for certification. In other words, the experience these companies needed in terms of operation hours was considered more important than the formal papers.

Manufacturers got around this problem by taking advantage of the industry's general lack of experience with certifications in China. Since the international certification companies, such as DNV GL and TUV, offered simple design assessments as well as more comprehensive type certification, manufacturers were able to fulfil only the quick version without developers noting the difference. The interviewee from China Certification General explained this:

> Some of them [turbine manufacturers] will seek a design evaluation or a prototype certification as defined in IEC standards. These evaluations look quite like the certificate and most of the developers don't recognise the differences between certificates and a design evaluation or a prototype certification. And a design evaluation is much quicker than a full certificate.

Thus, manufacturers were able to short-cut the long process of getting a full certificate from international companies. In practice, their turbines would go through testing after being sold, rather than being tested by certification agencies. In this way, the turbine manufacturers saved time and got the 'right' international documentation that helped them sell turbines on the domestic market. In this case, we may say that quality conformity was unimportant in terms of actual procedures, but made a difference in terms of 'face value' that sped up the commercialisation of the turbines and gave companies with these certificates and edge. In this process, there was a negotiation between speed and commercialisation that had consequences for the final product.

Quality was a concern in the industry, and many interviewees voiced that component suppliers did not manufacture according to European standards. One episode that was referred to by several of the foundation suppliers I spoke with was the ZPMC delivery of foundations to the UK offshore wind project Greater Gabbard in 2010. After the foundations were delivered, there were reports of quality problems relating to poor welds that needed repair (Reina, 2012). These poor welds created a bad reputation not only for ZPMC, but also for other Chinese suppliers. For instance, the interviewee from the small shipyard said that they had been bidding for a project in Denmark, but neither they nor ZPMC had won the bid, 'possibly because of the bad reputation from the Greater Gabbard'. This bad reputation could potentially persist even if product quality were to correspond to the highest standards, making it more difficult for the Chinese industry to catch up with frontier firms. Frontier firms also recognised that the reputation of Chinese companies was sometimes worse than the actual state of matters. For example, one foreign supplier of control systems confessed that many Chinese turbine manufacturers wanted a foreign control system because it was associated with quality – not necessarily because the quality was actually better. Thus, the reputation of bad quality must be taken into account as a possible factor that made opinions about quality more negative than the actual conformity to standards.

Nevertheless, reports of poor welding were also a topic in other interviews. When asked why this had occurred, some referred to low wages, some to poor training and some to short deadlines that had made some companies hire unskilled labour in times of rapid increases in demand. It appears, therefore, that the possibility and sometimes dire need to save money for Chinese suppliers directly affected the quality of their final products. This was also emphasised by component suppliers at all of the wind conferences I attended during my

stays in China. Roth et al. (2008, p.28) claim that Chinese suppliers are obsessed with keeping costs low, which 'helps to explain Chinese companies' swapping out of approved ingredients for cheaper substitutes or skimping on proper handling'. In the offshore wind industry, a story from a European coating firm in China stood out: 'Some of our clients want the most expensive and high-tech coating on the outside of the turbine, where it can be seen, but on the inside they will choose the cheapest one to save money'. Moreover, the time pressure suppliers were under to construct projects gave them less time to adapt. As one supplier representative put it: 'To adopt the parameters and the design is normally not very difficult, but the problem is that very often they [the customers] give us very little time for the design and for the production.'

Somewhat expectedly, therefore, the most frequent issues related to poor product quality were associated with cost-cutting – by offering low wages to workers or wanting to get products done in a short amount of time – and a bad reputation that was difficult to overcome.

6. Too close or too shallow? Relationships and quality

There were, however, other compelling practices that may have hampered a concern for product quality. These were revealed in observation of the wind turbine component suppliers. Wind turbine blades were amongst the most expensive wind turbine components, and, as Figure 4 showed, there were several domestic Chinese blade producers. As it turned out, Chinese-produced blades had quality issues, as stated by the interviewee from China General Certification:

> They just buy some design from Europe, in order to manufacture their blades, but the procedures, I think personally, are not quite well followed. So some of the blades have potential risks and today, after they have been in use for some years, there are more failures from the blades.

Several interviewees also expressed that there was a quality difference between products produced by domestic suppliers and those built by foreign suppliers in China. For instance,

a foreign professional performing inspections at several wind turbine component suppliers said that:

> My impression is that the foreign suppliers manufacturing here have greater control of the quality. For instance, I was inspecting a Taiwanese supplier and the conditions were perfect. And I have also inspected several Chinese suppliers here and I have several times detected problems with their procedures for quality control.

The difference, according to this inspector, mainly related to failed quality control procedures. However, the interviewee continued to point out a potential reason for the difference:

> One company I was visiting did not even seem interested in improving the points I mentioned, and I suspect the reason for that was their very good relations with their customer, the turbine manufacturer Siemens.

The interviewee explained that the company in question was supplying components for an offshore turbine produced by Siemens. The interviewee noticed that the person sent from Siemens to audit the component supplier had very good relations with the managers and that they frequently met socially. The importance of good relations has been demonstrated in other cases in China (Peng & Luo, 2000; Hansen, 2009b; Shi et al., 2014), and in the wind industry in particular (e.g. Korsnes, 2014; Søndergaard, 2015; Kirkegaard, 2015). In the offshore wind industry, good personal relations may have been more important than delivery of a perfect component. Hence, the close 'friendship' between supplier and manufacturer may have inhibited information exchange between them.

Other examples of failed communication due to close ties occurred when suppliers and buyers were part of the same industry group. Suppliers within the same group, as the following case with United Power and Longyuan shows, were able to deliver products that did not perform as well as competing products without repercussions. The developer Longyuan has the most experience with onshore and offshore wind energy in China. Their subsidiary, Guodian United Power, was, by the end of 2013, the third largest turbine manufacturer in terms of cumulative turbine installations, and had a 10 per cent market share in both onshore and offshore installations (WWEA, 2014). The poor performance of United Power turbines was a topic in several interviews, and there was a general consensus that the performance was not on par with other Chinese turbines. Longyuan had been the largest customer of United Power, and this had likely led to less feedback for turbine improvements. As an interviewee from the Chinese certification agency put it: 'Longyuan

have to buy the turbines from United Power; so I think this will give United Power less encouragement to improve their technology. They're not much driven by the market performance.'

A wind industry consultant commented that United Power's main problem was that they were 'manifestly incapable of understanding what an external client needs. They are selling almost exclusively to their own group, and they haven't been able to break out and sell to other groups.' An interviewee from a gearbox manufacturer explained the situation in this way: 'In China it is like this. If it can sell then it is good enough. If it cannot sell, then we will start to think, "What's the problem?" and then try to improve. As long as we can sell, we cannot always see what the problem is.' The problem was, therefore, that United Power was able to continue to sell their turbines to Longyuan despite their turbines' underperformance. Longyuan patiently supported United Power and, in this way, United Power grew quickly. However, United Power failed to convince other customers that their product was robust – something that was likely due to their very close ties with only one customer, their mother company. An interviewee from a competing wind turbine manufacturer explained the unfortunate relationship in this way: 'it can be compared to having a son; you want to support him regardless if he is talented or not.' In other words, the unchanging support from a state-owned company was useful in enabling them to acquire technology and hence grow to become a big turbine manufacturer, but was useless in ensuring a continual improvement in product performance and inter-firm learning, and hence catching up. Ironically, close ties were important for the success and growth of the company, but these same close links also hindered the improvement of quality. Having the technology and the right connections was therefore not the same as making the technology work.

International entrants and domestic companies manage their supply chains differently, and this may also help explain the underperformance of Chinese firms in terms of quality. Hansen (2009a) argues that domestic companies in China simply choose another supplier if a component does not accord to expectations, whilst international entrants typically cultivate a relationship and develop a component based on mutual feedback. Steinfeld (2004) also shows how Chinese firms integrate 'shallowly' in the supply chain. Looking at the offshore wind supply chain, we saw this distinction particularly between companies with larger and richer owners. For the more expensive components, small companies did thorough research

on which supplier to choose to reduce risk related to quality and faults. As a manager of a smaller wind turbine project developer put it:

> There are two types of bearings: one type is inside the turbine and it is very easy to replace. The other type is for the gearbox and the main frame, and it costs a lot of money, a lot of engineers and a lot of time to change it. This is the one we typically import.

This developer chose to import the expensive components in order to ensure quality. The larger developers, on the other hand, appeared less attached to suppliers outside their own group. A representative from a large SOE developer expressed it as follows:

> Maybe there would be a problem with a bearing, but, never mind, I will buy another kind of bearing from another producer. It's OK. Maybe I will lose a little money, but it is never big money. We can afford it. It is not a problem.

Having ample access to financing, large project developers had more slack in terms of suppliers, and did not necessarily mind trying local suppliers. Should the quality of a component not be adequate, they would simply try another supplier. This means that, in terms of local supply chain development, the large, state-owned developers actually gave local suppliers a chance. The problem was only that they did not follow up in terms of feedback and co-development if products were not as expected; hence, the relationship between supplier and manufacturer was 'shallow'. This is also supported by research from China's onshore wind industry. Lema et al. (2013) show that, in contrast to Europe, where many turbine manufacturers produce the majority of components in-house, the Chinese onshore wind turbine supply chain has a large number of manufacturers and a highly competitive environment. This competitive environment drives down prices, but also keeps relationships between suppliers and purchasers short-term (ibid.). Developing a product takes time, and, as the case of Denmark's wind industry showed, feedback between suppliers and manufacturers is crucial for cultivating relationships and convincing customers of the quality of a product (Garud & Karnøe, 2003). In other words, SOEs could have been supportive of domestic suppliers, but instead were 'shopping' for new components and failed to build the necessary competences through mutual feedback and collaboration.

Another aspect of these shallow ties pertained to supplier background. Several component suppliers were large multi-industry companies with experience in related industries. These large companies were sometimes not interested in including feedback from their customers

in the early stages. A representative from China General Certification explained the problem:

> If we take the gearbox manufacturers for example; they don't have much experience about wind dynamics in the early stage, since they typically provide gearboxes for ships or other industries. The wind industry is a smaller industry, as they see it, so they will use the existing experience to manufacture the gearbox for the wind industry, and they don't care much about the opinion in wind industry at the early stage.

These large multi-industry conglomerates regarded the wind industry as small and inexperienced, and felt that they knew everything they needed to know about gearboxes. However, this lack of feedback between supplier and buyer could cause several problems relating to turbine performance and optimisation. This was pointed out by a European advisory agency that had been hired as an independent third party arbiter in a dispute over where the responsibility of failing gearboxes should be placed. Including this last point on shallow, but rather arrogant, relationships between suppliers and manufacturers, Table 3 summarises the different types of relationships and the types of firms in which they occurred.

Table 3: Supplier-manufacturer relationships, and where they occurred

	Close	Shallow
No firm-specificity	'Friendship'	
Large-SOE	'Duty'	'Shopping' 'Arrogance'

In summary, we may conclude that a lack of feedback between suppliers and manufacturers was a reason why products did not perform optimally. These relationships varied between being too close or too shallow, and had different consequences depending on the types of firm supplying components and manufacturing. Table 3 provides an overview of the way in which company ownership could influence user and producer relationships, and ultimately product quality. Too close friendships that 'blinded' the manufacturer could occur within any type of supplier–manufacturer relation in China. However, relationships between suppliers and manufacturers within large SOEs were identified as being particularly prone to either too close or too shallow links that could stifle learning processes, because this may have happened through all four of the identified mechanisms. In addition to the 'friendship'

type, they may have also had close links that were characterised by ‘duty’, wherein they had no choice but to buy from a specific supplier. Shallow ties may have also occurred if the manufacturer practiced component ‘shopping’ or the supplier ‘arrogantly’ believed it held sufficient knowledge about the product. Firms in China should be cautioned against having too close or too shallow relationships. In effect, these are missed learning opportunities wherein quality might be improved if practices were to be different.

7. Conclusion: Technological learning and quality considerations

Summarising the findings in sections 4, 5 and 6, we can say that as China is catching up on offshore wind technology, several concerns complicate product quality. Section 4 showed that joint ventures and technology licensing from Western firms were frequent strategies used to acquire technology in the offshore wind industry. Section 5 then identified some ‘usual suspects’, such as time, revenue and reputation concerns, that complicated processes that would have ensured product quality. Time constraints were also an important reason why certification was seen as mostly a symbolic and impractical process. Therefore, in the offshore wind industry, quality conformity was unimportant in terms of actual procedures, but made a difference in terms of ‘face value’. Chinese firms saw the European standard as a quality benchmark, and turbine manufacturers opted for ‘quasi-certificates’ with a foreign stamp that were satisfactory for the project developers and that would give them an edge on the domestic market. For the domestic Chinese industry, foreign certificates were not as important as turbine installation. This may be interpreted as a strategy of learning through experience rather than waiting for the slower certification procedure.

A central finding of this paper is that links between suppliers and purchasers were unhelpful in ensuring quality in two ways: they could be too close or too shallow. In the former case, the relationship between the large state-owned enterprise Longyuan and its subsidiary turbine manufacturer Guodian United Power was used to illustrate ties that were so close that feedback was not used to improve product performance; Guodian United Power was the untalented son that received unrelenting support. On the other end of the spectrum, shallow ties led to ‘supplier shopping’ and a communication block, leaving scant possibility for the improvement and optimisation of components. The advantages of close and shallow ties

were that local companies were contracted. However, learning opportunities were missed in both cases: where ties were too close, there was a sense of duty or friendship characterised by too much patience, and where ties were too shallow, supplier shopping or arrogance was characterised by a lack of patience. We may therefore conclude that better feedback between supplier and demander could enhance learning processes and, ultimately, product quality.

By breaking down the way in which close and shallow ties influence learning within SOEs and enterprises more generally in China, this paper provides a novel insight into the way in which state ownership influences the acquisition of dynamic capability. Companies may invest all the time, money and engineers they want on R&D, but considerations of supplier–manufacturer feedback may still hamper learning processes. Moreover, we can also conclude that Lundvall's (2010) theory of interactive learning and the benefits of close and sustained interaction need to be nuanced: relations may indeed become so close that learning is hampered. In other words, a form of 'optimal' proximity must be found in order for interactive learning to occur. As the institutions of quality assessment in China are still developing, this paper only begins to trace the various instances that facilitate or complicate quality considerations. More research is needed in order to determine exactly what an 'optimal' relationship is, and how such relationships are characterised in China.

If Chinese companies are not able to make products that perform according to the intended criteria, they may end up jeopardising a shift towards more sustainable energy industries. Malfunctioning wind turbines are easy targets for the stronger and more stable coal power industry in China, and the momentum for renewable energy development may be reduced. However, the findings in this paper are not only relevant to the energy industry, but also to other industries, such as the food industry, in which communication and ties between suppliers are crucial for safety and quality (Roth et al., 2008). By going into detail, this paper has identified two practices that may influence the quality of a product in China. Acknowledging that product quality is an integrated part of a catch-up process, we may say that too close and too shallow ties between Chinese firms inhibit successful catch-up. The acquisition of dynamic technological capability often implies the production of sub-standard products until a certain point in time when the necessary capabilities have been acquired. Whilst for European companies quality may mean that a product conforms to established international standards, it appears that for Chinese companies, quality conformity

procedures demand resources and time that they do not have. As this paper has shown, Chinese companies have several other considerations that downplay the focus on product quality, and these considerations will likely continue to be important until the technology is mastered. For better or for worse, Chinese firms are trying to learn independent manufacture.

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Appendix: Overview of stakeholders in the offshore supplier segment

Segment	Company	Background and ownership	Central-SOE?
Foundations and installation	Jiangsu Longyuan Zhenhua Marine Co. (also installation)	Joint venture between Longyuan and ZPMC, a ship construction company	Yes
	China Offshore Oil Engineering Corporation (COOEC)	Offshore oil and gas structures, the largest offshore engineering construction company in China and part of China National Offshore Oil Company	Yes
	Nantong Ocean Water Conservancy Engineering (also installation)	Subsidiary of the Jiangsu Hantong Group, involved with maritime and offshore structures	No
	Jiangsu Daoda Heavy Industry (also installation)	Privately-owned shipyard	No
	CCCC 3rd Harbor Engineering (also installation)	Subsidiary of China Communications Construction Company (CCCC), a large group involved with the design and construction of transportation infrastructure, dredging and heavy machinery manufacturing	Yes
Vessels	Jiangsu Hantong Group	The company has, amongst other things, produced specialised installation vessels for offshore wind	No
	Shanghai Zhenhua Heavy Industries (ZPMC)	CCCC has a majority stake in ZPMC	Yes
	COSCO Nantong Shipyard	Subsidiary of the COSCO group, a shipping and logistics services supplier	Yes
Cables	Zhongtian Technologies Submarine Optic Fiber Cable	An optical fiber cable company supplying mainly to telecommunications and the electricity grid in China	No
	Qingdao Hanhe Cables	A company developing and manufacturing wires and cables	No
	Ningbo Orient Wires and Cables	A subsidiary company of the Orient Group, a privately-owned conglomerate	No
	Fujikura Shanghai Cable	A JV formed in 2005 between the Japanese Fujikura group and Shanghai Cable Works	
Coating	Only foreign suppliers		
Offshore sub-stations	Only foreign suppliers		
Developers	Longyuan	Subsidiary of Guodian, one of the five largest power and power equipment producers in China	Yes

	China Three Gorges	One of China's largest energy companies, engaged with hydropower projects	Yes
	Huadian	One of the five largest power and power equipment producers in China	Yes
	Datang	One of the largest power and power equipment producers in China	Yes
	China National Offshore Oil Company	The largest offshore oil and gas producer in China, with operations in more than 40 countries	Yes

Sources: Company webpages, BTM (2012).

Paper 3: Outside the European Box: China Developing Offshore Wind Technology

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Paper submitted to *Technology Analysis & Strategic Management, October 30th, 2015*

Abstract:

This paper examines the role of six European certification and advisory firms, and how they attempt to position themselves in China's offshore wind industry. These firms may be seen as intermediaries in technology development and innovation processes, and we examine their importance in an emerging renewable energy industry in China, offshore wind. European certification and advisory firms lack attention to local needs and struggle with differences in risk perceptions. Chinese companies, on their part, stress the importance of first-hand experience rather than foreign involvement in project development, making European certification and advisory companies redundant. We therefore conclude that the Chinese innovation strategy is radically opposed to that of the Europeans. From a Chinese perspective, the European approach looks like over-engineered project development, whilst in China taking risks is seen as a precondition for developing the offshore wind industry.

Highlights:

- European certification and advisory agencies have been unsuccessful in selling their services to companies in China's emerging offshore wind industry due to differences in risk perception, views on the service industry and lack of attention to local needs
- European certificates are unwanted in China because local companies stress the importance of experimentation and learning and want to gain first-hand experience
- Certification and advisory firms may be more important as knowledge brokers within an established industry than between industries in two different countries

Keywords: certification, advisory, intermediaries, innovation, China

Introduction

China is the world's most populated country, and 80 per cent of its electricity generation is fuelled by coal power (EIA 2014). This makes China the single most important country in terms of global greenhouse gas emission mitigation. The nation's almost insatiable electricity consumption is also one of the reasons why China is the world's largest investor in new renewable energy industries (FS-UNEP 2015). The offshore wind industry is one of the renewable energy industries in which Chinese companies are eager to get a head start. Such development is motivated by concerns related to ensuring energy security, developing industry and increasing the percentage of renewable energy in the energy mix as a way of cutting CO_2 emissions (Ydersbond and Korsnes 2014). The development of offshore wind energy is currently high on the agenda of many countries. Whilst the European Wind Energy Association set a target of 40 GW of installed offshore wind capacity by 2020 in Europe, the twelfth five-year Plan for Renewable Energy (2012) of the Chinese government had the ambitious goal of installing 30 GW of offshore wind capacity by 2020. The offshore wind industry is still a relatively immature industry globally, with Northern Europe the most advanced region and the Chinese coastline following as the only area outside Europe with large-scale offshore wind instalments.

In this paper, we study the development of China's offshore wind industry by looking at one specific group of actors that, in a European context, have played a central role for the development of offshore wind energy: certification and advisory firms. Certification has exploded over the past 25 years (Bartley 2011), and certification and advisory companies have been considered important intermediaries in technology development and transfer settings (Bessant and Rush 1995; Howells 2006). As risk and uncertainty have become fields to be 'managed' (Power 2007), certification and advisory firms have arguably gained an important role by providing evidence that a technology will function within a set of given conditions. Moreover, as certification firms certify products and processes according to internationally acknowledged standards, they may be seen as maintenance agents of standards (Timmermans and Epstein 2010). Nevertheless, there is a surprising lack of research critically assessing the increasing role that certification and advisory firm have taken.

Thus, by better understanding the roles and strategies of European certification and advisory firms in the development of offshore wind energy in China, we also aim at discerning how

these strategies may impact technology development in China. China's offshore wind industry here serving as a case in point, we aim at elucidating how certification procedures and advisory services are introduced and welcomed in a new setting, and how these impact innovation and technology development in China.

Certification, Advisory and Technology Development

Risk is a central concept to certification agencies. Risks are evaluated differently depending on criteria that are open for interpretation in different contexts (Pesendorfer 2011). Therefore, success in selling services related to risk reduction depends on the persuasive power of risk management companies (i.e. certification agencies) in convincing others that their knowledge will make products and processes safer. A subsequent question arises: How do these companies provide legitimacy for their endeavour? According to Busch (2011), legitimacy within an auditing system is nested in a circle wherein involved actors check on each other to ensure that standards are maintained. In this circle, certification agencies certify according to internationally acknowledged standards, and certification agencies are, in turn, accredited (i.e. certified) by international organisations. As Gustafsson and Tamm Hallström (2013) have shown, certification agencies gain legitimacy by referring to accreditation agencies, and these, in turn, continue to refer to higher sources of legitimacy (governments, member organisations and international organisations). Hence, as European certification agencies attempt to access China, they must make sure that: 1) risks are assessed similarly and 2) they, as certification agencies, are acknowledged as legitimate actors to carry out the certification process.

In terms of technology development, certification and advisory agencies can be grouped under the more general concept of 'intermediaries' (Howells 2006). Intermediaries can play various roles in an innovation process, but generally act as brokers between two or more parties at any stage in the process (ibid.). Moreover, it is generally established that intermediaries are important in the process of transferring knowledge and technology 'across people, organizations and industries' (Hargadon and Sutton 1997). In this paper, 'advisory agencies' refer to both engineering consultants that provide engineering-related services and to consultants or advisors that carry out industry analysis. These agencies are often part of the same group of certification agencies, although the two units are physically

separated and, strictly speaking, not allowed to collaborate. Advice often accords to the procedures and requirements of international standards, and is based on 'best practice' that has been acquired in other (here European) contexts. Advisory agencies are distinguished from certification agencies in that they are able to perform and contribute with tacit and explicit knowledge and experience. Certification agencies, on their part, merely point to issues that do not accord to standards without providing advice on how the issues may be resolved; hence, they often provide scope for advisory agencies.

Certification agencies certify products and processes according to a given standard. The development of standards is always contingent on local work, in the sense that each location develops and interprets their own standards. Thus, standards are not automatically universal, and Timmermans and Berg (1997, 275) have instead referred to *local universality*, as standards emerge from 'localized processes of negotiations and pre-existing institutional, infrastructural, and material relations'. Tensions between local practices and the universality of standards are central to this paper. A recent study by Ponte and Cheyns (2013) has shown that complying with standards or partaking in the development of standards can be more difficult in developing countries, as such countries lack resources or are not familiar with the 'rules of the game'. Differences in power and in understanding the 'rules of the game' may make the conditions for complying with, as well as developing, standards different for developing countries such as China. Moreover, certification agencies also take part in shaping international standards by participating in technical groups of international standardisation organisations (ISO and IEC) (Tamm Hallström 2000).

Some studies have focused on the way in which certification agencies participate in the development of international standards (e.g. Gustafsson and Tamm Hallström, 2012; Higgins and Tamm Hallström, 2007), and there have been several studies on the role of consultants in innovation processes (e.g. Sturdy and Wright 2011; Wright et al. 2012). However, little research has been done on the way in which intermediaries perform their work and on the way in which consultants actively work to get new clients (Pollock and Williams 2010). This form of active work to recruit clients becomes quite central in a new market context, such as China, where consultancy and certification services are not as common as in Europe. Knowing that certification and advisory agencies are intermediaries, we may therefore ask what role they play when approaching new markets. What strategies do European intermediaries employ to convince the Chinese of the necessity of their

service? Do Chinese actors view certificates and standards as advantageous? If not, how do they deal with them? Before we try to answer these questions, we shall explain the data and methods employed.

Method

This study is based on a one-year long fieldwork in Shanghai, China between May 2013 and April 2014, where one of the authors conducted altogether 31 interviews (see Table 1). The label 'entering company' describes the six European certification and advisory companies that were trying to establish themselves in the offshore wind industry in China. Each of these companies had both European and Chinese employees, and in each company Chinese, European or both nationalities were interviewed. 'Local industry and government' refers to the various domestic actors related to the offshore wind industry in China.

Table 1: Overview of interviewees

Group	Industry segment	Interviews
European employees of entering companies	Certification and advisory	6
Chinese employees of entering companies	Certification and advisory	6
Local industry and government	Government	7
	Turbine manufacturer	6
	Project developer	5
	Local certification bureau	1
	Total	**31**

Six of the interviews were conducted during two months of participant observation in Shanghai at a large multinational certification and advisory company that had originated in Northern Europe. In order to anonymise the company, it is here simply referred to as the Certification and Advisory Agency (CAA). CAA is a large multinational company that classifies, certifies and provides advisory services within oil and gas, maritime and energy industries. All names of interviewees have been changed to cater for anonymity.

Interviewing in China can be challenging, as Chinese respondents are very careful about saying something wrong or out of line with official policy (Solinger 2006). For this reason,

it is more common for respondents to answer in less concrete ways and to leave room for interpretation in their responses. Thus, in the analysis, some of the 'hints' and vague utterances from Chinese interviewees can be regarded as fairly strong indicators of opinions, though they may not sound like it. The language barrier (lack of English skills or interpreter-related issues) was another challenge. The interviewer attempted to deal with this challenge by asking questions in various ways or repeating the interviewee's response and asking for confirmation.

The data were analysed with the assistance of the analytical software NVIVO. Most interviews were audio recorded and transcribed verbatim, whilst some were recorded in notes. The interview data were analysed according to principles of 'abductive reasoning', meaning that both field data and existing theory were allowed to influence the researcher, but, ultimately, instead of forcing either the theory or the data into a framework, the researcher left space for his own logical reasoning (Reichertz 2007). The analysis is also inspired by constructivist grounded theory (Charmaz 2006), implying that the analysis started already at the data collection stage, and interview structures changed as a better grasp of the topics to be pursued was developed.

The paper uses narratives as a way of analysing and grouping the data collected in Shanghai. The narrative method is useful for distinguishing different modes of knowing and communicating in the interaction between European and Chinese actors (Czarniawska 2004). The narratives that are highlighted in this paper are 'stylised' and appeared throughout the analysis of the research in Shanghai. They are referred to as narratives because they are stories that have been shaped, reshaped and negotiated over time, and they can be attributed to attitudes or worldviews that cover more than one person (ibid.). In practical terms, this means that each interview is examined for patterns, similarities and differences in argumentation in relation to other interviews. Single, standalone arguments are not emphasised as much as the series of arguments that link events and ideas between actors (Riessman 2008) as stories are 'produced by the setting, in the broad sense' (ibid, 68). When a story is told and retold, some narrative building blocks become accepted ingredients, whereas others are excluded (Deuten and Rip 2000). In this sense, narratives are 'meaning-making devices' that connect available elements and link them into a meaningful whole (Gubrium and Holstein 1997) Moreover, they are performative, as they can mobilise people into action (Garud et al. 2014). The narratives identified in this analysis

are therefore recognised to provide meaning to the activities of the different actors, and, at the same time, to navigate their desired future outcomes through the means of communication.

Wind industry certification and advisory procedures in China and Europe

'Certification' in this paper refers to a procedure performed by an independent third party to ensure that the practices used in the production of a product conform to industry best practice; it is thus often referred to as 'conformity assessment' by the industrial world (Busch 2011). Best practice is often codified in the shape of international standards. The International Electrotechnical Commission (IEC) has, since 1987, had a technical committee (TC 88) working on setting international standards for wind turbines, the IEC 61400 series (IEC 2010). As of 2011, the committee had 24 participating countries, including China, and 12 observing countries, all of which contributed to the development of standards for design requirements, engineering integrity, measurement techniques and test procedures of wind turbines (ibid.). These standards, in turn, are used as the basis for the certification of turbines, which can be performed by an accredited third party.

In the wind industry, there is a distinction between type certificates and project certificates. A type certificate attests that a wind turbine and its components have been manufactured according to certain requirements. A company may also choose to get a design assessment (or evaluation), and this assessment is less comprehensive than a type certificate since it overlooks certain important stages related to testing and manufacturing the design (Woebbeking 2008). A project certificate is intended for a project with more than one turbine, and includes certification of not only a turbine, but also all of the necessary installations such as measuring masts, electricity transmitters, transformer stations and so on. A project certificate therefore ensures that the different components of a wind farm project are compatible, suitable and adequate. In Europe, project certificates are necessary for insurance, government approval and to attract finance; however, the scope for such certificates is close to non-existing in China, as shown in Figure 1.

Within China, testing new designs and selling turbines is possible without an international certificate. The reason for this is that complying to international standards early on can make technology development harder, as compliance requires much time and money and a

higher degree of foreign involvement. Apart from the government, the project developer, design institute and construction agency are the three most important actors in China. In Europe, in addition to these three actors, certification and advisory bureaus are very important for gaining financing and insurance and for complying with regulations. Since project developers in China are large state-owned enterprises (SOE) with strong financing opportunities, it is easier for them to get loans from state-owned banks.

Figure 1: Simplified overview of involved parties in project development in China and Europe

China also has two domestic certification bureaus: China General Certification (CGC) and the China Classification Society. Similar to the foreign companies, these bureaus provide certificates; however, they do not have experience with offshore wind projects. They certify products and processes according to the same international but their certificate is less acknowledged internationally. So far, they have certified only Chinese turbine designs. As was emphasised in many interviews, in order for Chinese turbines to be exported, clients demanded a certificate from a European certification body; this, in practice, limited the role of the CGC considerably.

In the next sections, we crystallise the narratives that each of the identified groups of actors circulated and negotiated. These narratives are: the narrative of the domestic industry named ‘Leave us alone!’; the narrative of the European entering companies saying ‘We are necessary!’; and the narrative of the Chinese employees of the European entering companies called ‘There is a middle way!’.

Narrative I: ‘Leave us alone!’

We observed an active resistance to European certification practices by local Chinese industry. The narratives of the local industry were quite specific on their ability to develop this industry on their own terms. They agreed that much could be learned from the European experience, but they wanted to perform the actual operations, themselves:

> Sometimes I have dinner and drink with the vice president of [a Chinese design company]. I talked with him and just made a joke that the developers say I can assess some design from your side, and he says ‘What, are you kidding? We are the best in China; we don’t need your assessment!’(Chinese employee CAA)

This quote illustrates a view put forward by many of the domestic design companies: they were confident that their competence was on the same level as that of the Western companies, and therefore did not need help despite their lack of experience with offshore wind projects.

However, some Chinese turbine manufacturers viewed international certificates as symbolic proofs of technology mastery, and as important for learning how to build the technology:

> Certification is taken as a symbol that one manufacturer has established their own capability for the design of a wind turbine. It’s a kind of symbol, so in the early stage people are following the certification process to acquire knowledge. The kind of knowledge or the know-how of what the procedure should be, what it looks like, and to educate their people of what kind of procedure they have to follow (interviewee China General Certification)

As the interviewee pointed out, Chinese companies followed international standards and certification procedures in order to learn the internationally accepted procedures. In this way, they learned the lay of the land and what was expected of companies elsewhere. However, as certificates were not needed in the domestic market, spending valuable time to gain a full certificate was seen as a waste. As the interviewee from China General Certification clarified: ‘A design assessment (for wind turbines) will do on the market, and it needs less time compared to full type certification. Full type certification is not a must currently.’ The Chinese companies only considered getting a certificate from a European company if they wanted to export their turbines.

Conversations with project developers – all large state-owned enterprises – emphasised the difference between Europe and China in their approach to project development:

> Generally speaking here in China the consultants do not play an important role because they do not really have any experience with the projects (…). We do go to some of the seminars [of foreign advisory agencies], and many foreign experts will show some cases. [These seminars] give us some inspiration, and we learn from them. But, in fact, there are only a couple of important points compared with the onshore wind industry. So we just have to focus on these very important points, and then it will be no problem. (Manager, large project developer).

From this we can interpret that the information and European knowledge was perceived as useful, but not needed. Moreover, challenges in offshore wind were not regarded to be so large and they saw only small differences between onshore and offshore projects. This mind-set was shared amongst the interviewed developers. Clearly, they were aware of some of the risks, but were eager to develop their own projects without the direct and detailed involvement of European firms. This suggests that the risks involved for the developers were regarded as necessary in order for them to attain the required knowledge. Risk-reduction was perhaps not desired precisely because, by accepting the European service, learning opportunities would escape the Chinese project developers.

Another interviewee from the large project developing company highlighted that local and political challenges were the main reason why foreign companies were inept to participate in projects:

> We have borrowed some ideas and experience from abroad too, but for the intertidal projects their technology wasn't very useful, so we had to construct our own vessels. In terms of technology there's much to learn from abroad. But for the pre-construction processes, such as policy, planning and approval, it is something we need to sort out here first.

The intertidal projects referred to here were projects constructed along the Chinese coast with no sea cover during low tides. European companies did not have any experience with such conditions, and Chinese developers had to develop their own designs for these projects. Since the intertidal challenge was overcome with domestic competence, Chinese firms were reluctant to accept advice from European companies with expertise in deep-water offshore wind projects.

Moreover, the above quote demonstrates that there was a difference between early-phase project development and project involvement. The Chinese saw themselves as knowledgeable about local policy and planning processes, and believed that foreign companies would not be able to assist in such processes. This was also probably a strategy

to give domestic players more time to get established, so they ultimately would not need foreign consultants. On the one hand, foreign service suppliers claimed that they needed to be included earlier in the planning process so that risks and costs could be reduced early on. This early-phase learning was emphasised as important by most of the interviewed Chinese developers, including Southern Offshore Wind Power Joint Development, a consortium of offshore wind project developers in the south of China:

> We have hired [a European advisory and certification company] for some inspections, and [another European advisory and certification company] for some consulting before. The thing is now in the beginning we have to test and do some experiments on our own in order to learn how to develop an offshore project. (Manager).

Thus, we found that the local Chinese industry underlined the need to have time to do their own experiments with developing offshore wind projects. Following this, they were clearly reluctant to let European companies take an important role early on in development. This means that Chinese companies largely resisted the effort of European companies to access the market and to introduce practices and procedures that had been acquired from European projects.

Indeed, we may say that Chinese companies assessed the risks differently than did the European companies. Chinese companies were interested in learning from European projects, but they were not interested in giving up responsibility for developing Chinese projects and the opportunity to learn how to develop these projects themselves.

Narrative II: 'We are necessary!'

In general, entering companies struggled to gain a foothold in the service industries in China. The entering companies were acutely aware of the difficulties of access, as several of the interviewees pointed out:

> One big barrier with the market here is that it is quite protected, and that Chinese companies are chosen in front of us. One example is [name of large Chinese developer] who consistently tried with local consultants, who never were able to solve the problem, and only in the end they came to us. (Manager, CAA).

This recurrent negligence of foreign expertise by domestic companies was only one of the voiced challenges. Other challenges related to project tenders demanding only Chinese project managers, as well as to tenders published only in Chinese, which were hard to discover in time, and to difficulties forging the right contacts. Another challenge was tied to

the fact that employees had to be available to a much higher degree than what would be demanded in Europe: Adaptation to the local situation and customs appeared to be a large part of entering companies' struggle to gain access. The entering companies were nonetheless certain that they could offer their services, and particularly so in the offshore wind industry:

> Generally they haven't done it [offshore wind projects] before and they don't know how to get from A to B. One of the problems for us is that some of them are very big organisations and you know, they're very proud of their organisations… They sometimes believe that they… don't necessarily need as much help as perhaps we think they do. […] Where they really need us is when they haven't done it before and you see they literally haven't even designed an offshore structure before; suddenly we become much more valuable in that case. (European advisor, CAA).

This quote underlines the overall finding that the Chinese were perceived as a bit stubborn, wanting to solve things without the help of others. However, the entering company claimed to have experience that could help the Chinese avoid large costs, risks and time-usage. In fact, the attitude towards local companies was that they were 'arrogant':

> We have connections with many of the big players, such as [large Chinese developer] and some provincial governments. But [large Chinese developer] are quite arrogant currently in the sense that they think they can do everything on their own. 'We have never done this before, but we are sure we can', you know. Perhaps attitudes might change if or when they experience the first big fail, and then realise the true value of experience and consultancy services. (Regional manager, entering company)

Hence, one of the strategies of the entering certification and advisory companies appeared to be waiting for the Chinese industry to fail. It is interesting to note, moreover, that there was a firm belief that Chinese companies' lack of attention to risk would, in the end, lead to disaster – disaster that could be avoided, the European companies argued, should their services be welcomed.

Compared to the advisory business, which had a small selection of offshore wind clients, the certification business was the industry that the European companies put the most effort into selling. Entering companies were quite confident that they would succeed in providing project certificates to local customers. The challenge was identified as the Chinese offshore wind project developers' lack of prioritisation:

> In Germany you need project certification because otherwise you will not get permission to build the wind farm. So there it is quite obvious that you need project

> certification. In China, they just start, and they don't really think about risks. So project certification is not needed. But anyhow we want to establish some services, like risk assessment. But project developers here don't have any budget for that. […]. So what we are trying now is to make them aware of some risks, and identify some of our services that we can offer separately. (European advisor, CAA).

We see from the above quote that, though the employees were aware that their services were not really wanted in China, they still tried to offer some of the same services they offered in Europe. One strategy was therefore to make the Chinese aware of the perceived risks. The need for certification was displaced with a new goal: minimising risk and the extra costs that accidents would create. Moreover, in order to appear less intimidating and to gradually make Chinese customers realise the value of their services, they chose to offer smaller service packages instead of large ones (such as project certificates). The idea was clearly that it was only a question of time before their services would be asked for, since the Chinese were perceived not to care as much about risk as did Europeans. One of the advisors in CAA expressed that: 'The Chinese style is just really different to what we do in Europe. In Europe we are very risk averse, but here they are much more, you know, "Just get on and do it".'

The company believed that they could make the Chinese more concerned about risk, as managing risk appeared to be crucial for achieving development. Chinese potential customers, on the other hand, appeared to be willing to take more risks and to learn and adapt during the process. These opposing stances of risk-taking in order to learn versus containing risk were also recognised by the European employees of CAA.

An interview with a European regional manager of an advisory agency made it clear that the company was afraid of losing relevance in China should their local competitors no longer see a need for them:

> Another risk is that we are training our own competitors. We need to make sure we train them in a way so that we are not out of business in some years. Chinese engineers are good engineers, and they learn quickly.

The training he referred to was a service they provided to local design institutes: training in basic offshore wind development techniques, risks and procedures. The danger was, therefore, that the local company would acquire enough competencies to render the European company unnecessary. The overall strategy of consultancy and certification companies trying to enter China was naturally to profit from their European experience and

to convince potential Chinese customers that their services were sorely needed. However, they failed to see how getting involved early conflicted with the goal of making the Chinese clients understand the risks: if the Chinese were indeed allowed to 'try and fail', the Chinese companies might learn enough to make the European companies obsolete. This was the implicit concession the European companies made by recognising the importance of entering China early.

Hence, the European certification and advisory companies were not very successful in soliciting Chinese clients. Their services were not needed and the strategy of waiting for an accident did not prove effective. Another strategy had to be found, and one such strategy was to convince the local employees, as we will see in the next section.

Narrative III: 'There is a middle way!'

All the interviewed entering companies had a majority of local Chinese employees in their Chinese offices. Throughout the fieldwork it became apparent that the local Chinese employees were constantly exposed to the narrative of the European entrant, but at the same time very much in touch with the local Chinese understanding of the situation at hand. Chinese employees of the entering companies therefore had a mediating role between the entering companies and the domestic industry. As one Chinese manager expressed it: 'I try to harmonise expectations from both sides, and sometimes the expectations need to be controlled.' The Chinese employees appeared to have a good perception of the local clients' wants and needs, and consequently what they thought about acquiring services, such as certification and advice, from a foreign company. The general observation was that these kinds of services were not easily sold in China, as expressed by several of the interviewees:

> The developers have little desire to hire consultancy or supervision services. This is a general mindset of Chinese people because the consultancy service is like additional, an extra cost. (Chinese manager, European entering company).

As this quote shows, the extra cost related to consultancy was regarded as unnecessary, since the companies believed they were capable of fixing most problems themselves. A similar, but yet, different sentiment was voiced by another Chinese manager from a foreign consultancy company:

> It is quite hard to sell services in China, because the Chinese prefer physical things that you can see, and not only what's in your brain. So we really need to convince people of the necessity of our services.

Hence the technology, *as a physical entity*, counted most in China, and any accompanying *mental activity* was considered something that could be learned quickly. Consequently, it was difficult to sell the consultancy service as such service was first and foremost regarded as an additional cost that was intangible and perceived unnecessary by the local companies.

As we saw in the previous section, the entering companies were concerned with entering early, before local companies had learned enough to make their services superfluous. This was also stressed by the Chinese employees:

> If we do not join the first projects or we do not deliver properly, then we may also lose this market totally. You can see this in the construction industry […] there are no Western companies there. […] So we have to give them a similar price to the local companies, easy communication, and localise. (Chinese business developer, CAA).

Offering competitive prices and facilitating communication by hiring local employees were strategies employed by the entering companies to attract clients early on. Interestingly, this interviewee drew a comparison with the construction industry, which had no foreign consultancy and certification companies; hence, his interpretation was that European companies had not entered early enough. The idea seemed to be that entering companies could integrate only by forging a business relationship early on, because after three to five years the Chinese would be able to do everything alone:

> After three to five years with several project experiences, the developers or manufacturers can deliver or implement the project themselves individually. But, if we get involved in the first stage, we would develop some kind of relationship, and we can always provide some service. [...] The basis is that you already have a relationship with Chinese offshore [companies]. (Chinese consultant, European entering company).

As the quote shows, Chinese manufacturers were, over time, expected to be able to produce most of their projects alone, without the help of foreign firms. In order to become interesting quickly, the entering companies saw the need to 'develop a relationship' with local companies. The strategy was quite unclear, however, as to exactly how such relationships would be established and developed.

One of the topics that created some friction between the European and Chinese employees of the entering companies was the suitability of offering project certification in the Chinese market. On the one hand, European employees were quite certain that they should aim to provide the service, like in Europe. Chinese employees, on the other hand, were not so enthusiastic about the idea:

> The first time I had a meeting with [the European headquarters] in 2009 the boss told me, 'you have to develop a project certificate'. My answer was no. At that moment it was quite clear. No market, no driver, no clients. I said we have to start from the type certificate (Chinese certification manager, CAA).

Thus, a type certificate was seen to be easier to sell than a project certificate. This was in 2009, and the European strategy was to provide project certificates for Chinese offshore wind projects. The interviewee was quite confident that this was not the right strategy. Instead, he approached the issue differently. The Chinese certification manager of CAA chose to rebrand the service by calling it 'risk management', rather than issuance of a project certificate. In other words, he replaced the European practice of certification to a more general concern over risks:

> I tried several times to advertise the project certificate [to Chinese clients] and they were not really interested, because they don't need financing from a bank. But they care about the risk, and they care about the cost. Also a lot of developers do not really understand what a project certificate is. So I just repackaged it and don't talk about project certificates. Instead, I refer to it as risk management; maybe change the words (…), and developers are really interested in that.

As this quote shows, risk perception was again at the centre of the story. Chinese clients cared about risk, but they did not pay attention to how project certificates would reduce risk. It appeared that risk, to the Chinese, was connected more to costs, and project certificates did not address this concretely enough. In any case, we see that the narratives of Chinese employees of European companies were modified so that Chinese interests were accommodated. Chinese employees were more consolidating and less certain about the 'right' approach to the market, acknowledging that the narrative needed to be amended in order to succeed. In other words, they were aware that the strategies needed to be translated in accordance with the visions and needs of Chinese companies and their local practices and understanding of services. However, over the year spent in Shanghai, the Chinese CAA manager quoted above enrolled more and more into the narrative of the entering company, going from being quite certain that project certificates were unsuitable in China to being

more convinced that project certificates could be sold there. To the entering companies, however, it appeared impossible that their procedures and standards would not be wanted in China. Hence, local Chinese employees were needed in order to make their approach fit with the Chinese market. In this way, the narrative of the entering companies was negotiated and adapted to local matters of concern.

A Chinese innovation strategy

This paper has shown through the narrative 'We are necessary!' that European advisory and certification companies have been relatively unsuccessful in making Chinese clients see the necessity of their services. In our analysis, the narrative 'There is a middle way!' suggests that some Chinese employees of these companies are trying to reframe the necessity of the European experience in China by referring to potential risks related to developing offshore wind technology. Nevertheless the narrative 'Leave us alone!' demonstrates that the local industry evaluates the involved risks differently, as they want to learn from own experiences. Altogether, this urges us to question role of European certification and advisory companies in China. As we have seen, Chinese companies are already taking international standards into consideration when manufacturing products. They are using codified standards to learn about procedures that are required for certification by an international company. Although knowledge about best practice is useful, a certificate from a foreign company appears to be neither required nor desired in the domestic market.

The major contribution of this paper is to demonstrate how and give some answers to why European certification and advisory firms fail in selling their offshore wind services to Chinese clients. Project development procedures and project certifications are important in a European context, so it is clearly surprising to the European companies that their services are not considered important in China. The experience that European companies have is useful, as it may allow Chinese firms to learn from European mistakes. For the Chinese companies, however, this learning comes at a price in terms of money and, more importantly, missed opportunities of getting hands-on experience. Chinese companies do not see it necessary to rely on European companies for the more complex parts of a project, as they believe they are independently capable of understanding the technology and developing domestic procedures and standards. For Chinese companies to gain access to European experience they must give European actors more control; this would imply less

tangible learning for Chinese firms. In this sense, European companies want to be seen as a necessary gateway for Chinese companies to comply with the international standards that have been developed by the same European certification agencies. However, as the analysis shows, they have not succeeded in achieving this position.

Whether Chinese companies engaged in offshore wind development will succeed with their current strategy or experience large failures that require European companies to 'come to the rescue' and thereby demonstrate the necessity of their services is yet to be answered. Nonetheless, China appears to be in a disadvantageous position in terms of influencing the shape of international standards. According to Ernst (2011), this may have negative consequences for the prospects of 'indigenous innovation' in China. However, on a general level, we can learn from the analysis that the Chinese innovation strategy is radically different to that of the Europeans. From a Chinese perspective, the European innovation strategy relating to offshore wind looks like over-engineered project development. This stands in contrast to the Chinese innovation strategy wherein taking risks is seen as a precondition for development.

A Chinese innovation strategy therefore implies acknowledging that there is no simple, straight-forward and risk-free road to develop a domestic industry and at the same time mastering the technology and innovating. Failure must always be regarded as a possibility, and an important implication of this paper is therefore that the right design for risk regulation must be evaluated locally. Further on, in a system that closely connects finance and insurance with government-owned enterprises, risk in a Chinese context relates to more than low-quality components or a lack of project management experience. For Chinese companies engaged in offshore wind development, there is also a risk connected to engaging in too much help from abroad – a risk that is perhaps regarded larger than the risk of failing to develop a project the first time around. Thus, our findings underline the different evaluation of risk between China and Europe that means that certification and advisory agencies are not similarly acknowledged as legitimate actors in China and Europe. However, this does not rule out the possibility that certification and advisory agencies will be seen as necessary at later stages in the technology development process. The likelihood that such companies will be of foreign origin may, however, not be large. This last argument points to the role of 'intermediaries' in technology development: intermediaries may be more important within an established industry than between industries in different countries.

Although international standards prove important to learn from, certification and advisory agencies are not important knowledge brokers in the emerging phases of China's offshore wind industry. In this phase it appears as though keeping control of the process is more important than managing 'European' risks.

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Paper 4: Ambition and Ambiguity: Expectations and Imaginaries Developing Offshore Wind in China

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Accepted (major revision) in *Technological Forecasting & Social Change*. The following version is the original manuscript that was submitted.

Abstract:

This paper investigates how future-orientation generates action in China's offshore wind industry. We might expect that, with an authoritarian government, China would be able to push through policies with ease. Using the sociology of expectations and sociotechnical imaginaries, this paper shows how the future is an important resource for not only coordinating government and industry actors, but also calibrating and negotiating expectations of what can be achieved. On the one hand, sociotechnical imaginaries – as exemplified by government development targets – appear to spur action; on the other hand, local expectations modify the intended development targets. The paper describes a strategic waiting game in which the government remains obscure and ambiguous about intentions, and in which the industry, wanting a piece of a promising cake, is eager to get a head start. This paper finds that ambitiousness about the future, but ambiguity in implementation, is a strategy employed by the government to ensure change. Sociotechnical imaginaries may therefore not only be characterised as formulations of attainable and desired futures, but also as concrete planning tools.

Keywords:

Sociology of expectations, sociotechnical imaginaries, Chinese policymaking, offshore wind technology

1. Introduction

Since 2002, China has actively supported the development of large-scale renewable energy – particularly wind power. China's constant need for energy and energy security is a primary reason for the development; other reasons include the country's need for new industry and the mitigation of local pollution and climate impact (Ydersbond and Korsnes, 2014). In 2009, the Chinese government and relevant stakeholders met to plan the development of China's offshore wind industry (Korsnes, 2014a). In 2012, industry analysts at the Offshore Wind China conference registered a pipeline of 37,000 megawatts (MW) of offshore wind projects in China, suggesting a rather large development compared to the approximate 300 MW of offshore wind projects that were installed at the time. Nevertheless, since the first turbine was installed in 2007, China's offshore wind industry has developed more slowly than expected. By the end of 2013, China had a total installed capacity of only 400 MW – much less than the capacity set out in the government development plan (WWEA, 2014) , and by the end of 2014 the government announced that the intended 30 000 MW target planned installed by 2020, will now be reduced to only 10 000 MW (Smith 2014). This paper aims at understanding the dynamics between ambitious government goals and promises on the one hand, and actual development on the other.

For developing countries, Western countries offer a very specific manifestation of what the future might look like. Countries such as China want to fast-forward their progress to reach certain characteristics that will qualify them as developed. There is therefore quite keen future-engagement in China, where project developers and government officials seek to look a bit further over the horizon in order to be one step ahead (Dodson, 2012). At any given time in China, an industry can become momentous or remain stagnant. Thus, large margins of error are necessary in predictions of the future. This is clear from an examination of China's onshore wind industry during the early 2000s. At that point, it was still unclear whether the industry would take shape. Lewis (2003, p. 84) wrote that: 'today with more wind projects cancelled than new projects sited, expectations are less optimistic. National targets for wind power in 2000 were not met, and it is even less likely that China will meet the target of 1,500 MW by 2010.' Knowing today that China installed 1,266 MW in 2005 and 2,599 MW the following year (Li et al., 2007), one may confidently say that the expectations of professionals in 2003 were completely shattered only two years later. The

comparison with the offshore wind industry of today is striking. This retrospection shows that, in spite of the divergence between government targets and other expectations of the future of the wind industry, the industry grew quickly. What role did government targets have in this development, and how did industry actors expect things to develop? How can we make more sense of this uncertainty of change in China?

In order to attempt to answer these questions, the paper draws an analytical difference between 'industry' and the 'government' as distinct but interdependent actors. Correspondingly, I employ the literature on visions and expectations to denote a difference in expectation levels. In order to study the role of the government in developing offshore wind in China, I use the concepts of a 'sociotechnical imaginary' (Jasanoff and Kim, 2009) and the 'sociology of expectations'. A sociotechnical imaginary is an arena in which norms and active government regulation shape industry actors' policy preferences for the future. The role of the government is particularly relevant for two main reasons: first, renewable energy industries are dependent on government support globally; second, China has an authoritarian government in which the role of government is prominent. This makes China a very specific context, and one may question the extent to which the analytical concepts of visions and expectations have any bearing on China's drive for change. Can we perhaps expect the government to run the show and push through policies without these expectations? In other words, what are the dynamics of expectations in China?

The structure of the paper is as follows. Section 2 presents the concepts of the sociology of expectations and sociotechnical imaginaries, and section 3 describes the method and data. Section 4 shows the difference between imaginaries and expectations in China's offshore wind industry, and explains the origins of expectations about the future of the industry. Section 5 analyses the way in which the government uses ambitiousness and ambiguity about the future as planning tools. Section 6 concludes by pointing out the usefulness of thinking about China's future in terms of imaginaries that can manifest themselves as 'loose' plans.

2. Imaginaries and expectations

The literature on technology and future expectations is growing, and concepts span several disciplines. Besides 'expectations' (Brown and Michael, 2003), there are 'visions' (Gjøen, 2001), 'promises' (van Lente, 2000), 'anticipation' (Gustafsson et al., 2014), 'imaginaries'

(Jasanoff and Kim, 2009), 'foresight' (van Lente, 2012) and 'fantasies' (Sovacool and Ramana, 2015). Many of the concepts overlap, but I shall look in particular at sociotechnical imaginaries and the sociology of expectations. I aim at demonstrating how the two approaches can be useful analytical tools to highlight different aspects of the future-orientation of offshore wind development in China.

The sociology of expectations explores the various dynamics of expectations relating to science, technology and society (Brown and Michael, 2003). Expectations and visions not only formulate, but also constitute and accommodate a desired future (Borup et al., 2006). Expectations at once legitimise a technology, point out a development direction and help coordinate interests that can materialise into technical and scientific activities and products (van Lente, 2012). Van Lente (2000) describes a dynamic of 'promise and requirement', implying that commitments become part of a shared agenda that requires action in itself. When promises are made, they subsequently become required achievements and, finally, necessary to either complete or continue work on; in other words, they become self-fulfilling prophecies (ibid.). This is not to say that any vision may become self-fulfilling on its own, but, rather, there is often substantial and active work behind making the future and aligning expectations.

Although many visions fail to materialise (see, e.g., Geels and Smit, 2000), many visions do succeed. What characterises a successful vision, and how is it performed? Several researchers have addressed this question. Berkhout (2006) describes 'expectations' as bids for the future that offer a potentiality requiring endorsement from others to be actualised. In this way, interpretive flexibility remains, enlarging the likelihood of greater support and potentially becoming larger and more normative and collective visions located in 'art and literature, public and political discourses, statements and appeals from business, civil society and government' (ibid, p. 307). Pollock and Williams (2010) explain how certain actors make a business out of future-orientation, and work as 'promissory organisations', systematically coordinating expectations. Promissory organisations are typically industry analysts who 'routinely and prodigiously produce future-oriented knowledge claims' (ibid., p. 532). These organisations do not directly try to generate promises about the future, but, rather, they circulate expectations that others have generated, emphasising existing expectations. Skjølsvold (2014) stresses that futures are resources that spokespeople of a technology can draw on to reach goals. These futures are performative in two ways: they

enrol and convince new actors and they gradually transform the idea of what a technology could mean for the future, and nest it with more purposes than were inherent in the initial idea. In this sense, an offshore wind turbine, for instance, is not only 'electricity', but also a 'sustainable lifestyle', a 'green' image that China can show the world and so on.

Expectations may also be contradictory and may fight to conquer the future in order to stay relevant (Bakker et al., 2011; Eames et al., 2006). This is not necessarily a weakness, however, as scenarios are malleable and can be used to build support from various quarters (Sovacool and Ramana, 2015). Moreover, as has been pointed out by several expectations scholars (e.g. Geels and Smit, 2000; Gjøen, 2001), some promises are set unrealistically high in order to generate interest and a protected 'space' for the technology. Though unrealistic, these promises are useful for the spokespeople of a technology, as they may impact the way people think about a topic (Berkhout, 2006; Pollock and Williams, 2010). As Geels and Smit (2000, p. 883) put it, 'some future speculations do not strive for truth or accuracy, but are meant to influence specific social processes in technological developments'. These expectations are therefore part of strategic games (ibid.), wherein the spokespeople risk that their 'bluff' will be called.

Expectations and visions are received and generated at different levels. According to Budde et al. (2012), diverging strategies chosen by industry actors and governments are the result of a difference in expectations related to various levels. Budde et al. (2012) show how governments typically refer to larger expectations of 'climate change' or related issues when making their decisions, whilst industry actors have more grounded expectations of the future of a specific technology. In addition, within governments there are competing expectations as to what should be deemed the most suitable technology (Bakker et al., 2012). There is, therefore, a difference between collective and individual expectations (Konrad, 2006; Konrad et al., 2012). Individual expectations are limited to the individual, whilst collective expectations are taken for granted, depersonalised and universally accepted. Examples of collective expectations are 'progress' or 'development', and most people share a similar perception about what they mean for the future. In this way, we understand collective expectations to be present in individual expectations, and for collective and individual expectations to mutually inform each other (Gjøen, 2001). Bakker et al. (2012) point out that the credibility of expectations depends on their similarity to the existing collective images. If they are largely dissimilar, they will be regarded as incredible.

As expectations become taken for granted, they become able to mobilise a larger number of actors – even actors who do not necessarily benefit directly from the expectation (Konrad, 2006). Eames et al. (2006) use the word 'vision' to denote a coherent image of the future intended to generate long-term action, whilst expectations of such images are less formal and include more fragmented beliefs about the future. They find that the overarching vision of a 'hydrogen economy' is justified by a range of narratives, varying from concerns of democracy, independence, environment and power to views of governments, businesses and research communities. As the vision is brought down to a local level, however, each narrative is drawn upon to generate interest or disinterest, impacting the way in which the guiding vision is perceived. Local expectations, therefore, impact the guiding vision. A vision such as the 'hydrogen economy', which has become so popular that it can be equated with nationhood and is supported by research and development programmes, also generates expectations about the vision, itself.

Several recent studies have pointed to the different roles of the government in collective images. For instance, Alkemade and Suurs (2012) point out that governments are more prominent in discourses and expectations related to sustainable technologies. Bakker et al. (2011, p. 159) describe an 'arena of expectations' wherein expectations are voiced and tested and spokespeople and potential receivers of a technology are 'confronted with experience, knowledge, and interests'. Within these 'arenas of expectations', state–industry arrangements function to make certain expectations more credible than others through exchanges between the government, industry and consultancies (Levidow et al., 2014). Jasanoff and Kim (2009, p. 120) use the concept of 'sociotechnical imaginary' to define 'collectively imagined forms of social life and social order reflected in the design and fulfilment of nation-specific scientific and/or technological projects'. The concept was originally coined by Marcus (1995), but I employ it here in the sense developed by Jasanoff and Kim (2009), who emphasise the importance of governments in simultaneously describing and prescribing an attainable and desirable future.

The 'sociotechnical imaginaries' concept emerged from a growing recognition that expectations of future possibilities are embedded in the organisation and practice of science and technology (Jasanoff and Kim, 2009, p. 122). Imaginaries are characterised as less instrumental than policy agendas, but more instrumental than grand narratives, and they 'reside in the reservoir of norms and discourses, metaphors and cultural meanings out of

which actors build their policy preferences' (ibid., p. 123). Imaginaries are futuristic and direct actors towards a desirable future. State power is a central 'director' of desirable futures through various means, such as the 'selection of development priorities, the allocation of funds, the investment in material infrastructures, and the acceptance or suppression of political dissent' (ibid., p. 123). Moreover:

> National imaginations can penetrate the very designs and practices of scientific research and technological development. And the resulting politics of science and technology may shape not only the narrow issues surrounding those specific enterprises but also wider social and political understandings about a nation's past, present and future. (Jasanoff and Kim 2009, p. 124)

China may offer one of the best examples of science, technology and development shaping a nation's understanding of its past, present and future. Previous research has indicated that governing mechanisms in China are used to guide industry outcomes (e.g. Korsnes, 2014b; Lema and Ruby, 2007).

To summarise, expectations can work to break new ground, create protected spaces, be self-fulfilling and mobilise new actors to support or oppose a technology. We can assume that collective expectations are malleable and can be drawn upon by governments. Expectations can also be contradictory, and we can expect the Chinese government and industry stakeholders to attempt to make certain expectations more credible than others. These expectations, in turn, impact the government supported visions. We can expect sociotechnical imaginaries to be present as general understandings of good and desirable futures in the social world, writ large. As we turn to look closer at China's offshore wind industry, we may ask what the important elements of successful visions are in this context. Do imaginaries fit with the way in which the Chinese government supports national science and technology projects, here exemplified by the offshore wind industry? How do these strategic games occur in China, and to what extent do promoters of visions tend to overestimate the future of their technology?

3. Research method and data

This paper is based on interviews conducted during one year of fieldwork in China from 2013 to 2014. Important observations were also collected at the China Wind Power 2011 and 2013 conferences, the Offshore Wind China 2012 and 2013 conferences and the 8th China (Shanghai) International Wind Energy Exhibition and Conference in 2014. I also

participated in workshops and meetings on offshore wind, at which I conversed with experts and professionals in the offshore wind industry in China and globally. The interviews focused on the participants' perspectives on the offshore wind industry, such as its challenges (including quality or management issues) and its comparison to the onshore wind industry. All interviewees were asked about the future prospects of the industry and whether or not the official government development targets for 2015 and 2020 would be reached. In order to present a broader view of the expectations made in the wind industry, this paper also includes twelve interviews from 2011 that focused on the development of China's *onshore* wind industry. With these included, there were 55 interviews in total.

Below is an overview of the interviewees and their respective stakeholder segment in China's offshore wind industry. Interviewees from the government included persons working with offshore wind in industry associations, local governments, provincial governments and central government agencies. Each interview lasted, on average, 70 minutes. All interviews were conducted in English, but only three of the interviewees were native English speakers. Use of an interpreter can make it difficult to ensure that a question is understood as intended, and that the answer is correctly transmitted. Moreover, use of a second language may cause interviewees to say things they do not mean, or may tweak the meaning of what was originally intended. These two caveats were taken into account and dealt with by repeating questions or clarifying meanings in instances in which there was any doubt. I am therefore confident that the following analysis represents the views of the interviewees.

Table 1: Overview of interviewees

Industry segment	**Interviews**	**Number of interviewees**		
		Chinese	**Foreign**	**Total**
Government	11	14	1	15
Turbine manufacturer	11	12	1	13
Turbine supply*	3	2	1	3
Advisory and certification	17	8	8	16
Balance of plant**	8	12	0	12
Project developer	5	9	0	9
Total	55	57	11	68

*Turbine supply includes gearbox, pitch and yaw systems and control systems.
**Balance of plant includes forecasting, electricity grid, coating, cables, installation and foundation and research.

The interview data were analysed according to principles suggested by 'abductive reasoning', meaning that both field data and existing theory were allowed to influence the researcher, but, ultimately, instead of forcing either the theory or the data into an uncomfortable framework, the researcher left space for his or her own logical reasoning (Reichertz 2007). The analysis is also inspired by constructivist grounded theory (Charmaz, 2006; Clarke, 2005), implying that the analysis started already at the data collection stage, and interview structures changed as a better grasp of the topics to be pursued was developed. This enabled a greater focus on topics of interest throughout the data collection, and it made coding easier, as all the data had been gathered. The data was analysed and coded using the computer assisted analysis tool NVIVO. Coding through NVIVO occurred after all the interview material had been gathered, and before much theoretical search had begun. The data analysis was guided by existing theories and was based on grounded concepts.

The analysis is structured as follows. Section 4 first explains how government induced imaginaries and local expectations were imaged in China, and how they were related. Section 5 then explores how these expectations were generated. Section 6 shows how a strategic waiting game induced change in China, despite uncertainty about the future.

4. Government targets, imaginaries and expectations

The ambitious government targets for the development of China's offshore wind industry appeared to be strong indicators of the future for industry participants. It may be argued that political support is more important than economic support for industry development in China (Korsnes, 2014b; Shi et al., 2014). If an industry receives attention from the central government, then the legitimacy and status of the industry is elevated on a provincial and local level, and the likelihood of its success increases (ibid.; Kong, 2009). Government targets are also important for attracting new investors. A common perception in the industry was described, in 2011, by an interviewee from the Global Wind Energy Council based in Beijing: 'If I am an investor and I want to invest either in solar, biomass or wind in China, I would go to wind because it has a really high development target.' Hence, the government has an important role when it comes to effectively creating sociotechnical imaginaries in China.

Figures 1 and 2 illustrate the difference in sociotechnical imaginaries and expectations. Figure 1 displays estimates of the development of China's offshore wind industry in 2015 and 2020. The 'government' indication is based on feedback from various government employees working in renewable energy policymaking, and the 'industry' indication is based on interviews and conversations with offshore wind turbine manufacturers, supply chain stakeholders and project developers. As we can see, the 'industry' estimates are more ambitious than those of the 'government'. The estimates from two industry analysis and consulting agencies, MAKE and GlobalData, are also included in the figure in order to show the way in which their predictions differ from those of 'industry' and 'government'. In this way, we cover all of the actors of the state–industry arrangements described by Levidow et al. (2014). In Figure 2, the government targets for 2015 and 2020 are greatly simplified to signify sociotechnical imaginaries, whilst the indications and estimates that appear in Figure 1 reflect more local expectations.

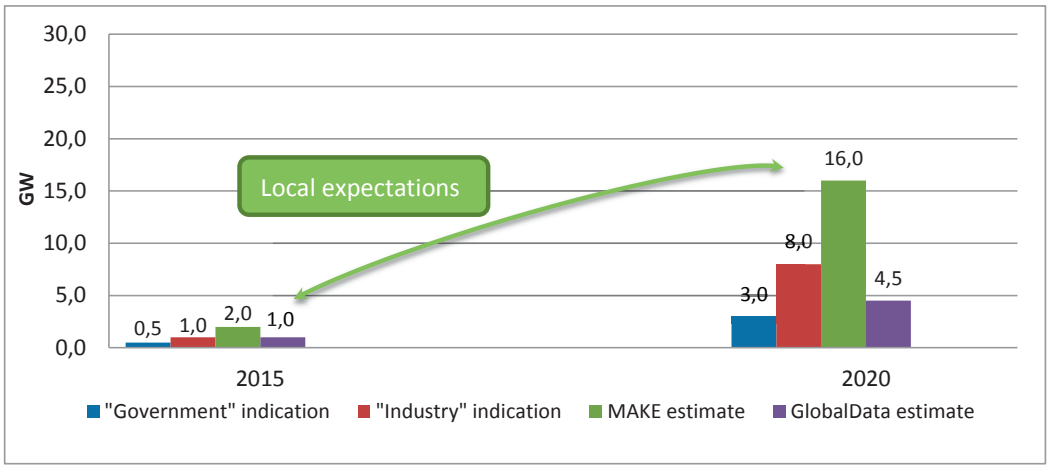

Figure 1: Projections of cumulative installed capacity in 2015 and 2020 in gigawatts (GW)

Source: Author's data, GlobalData (2013) and MAKE consulting (2013, p. 23).

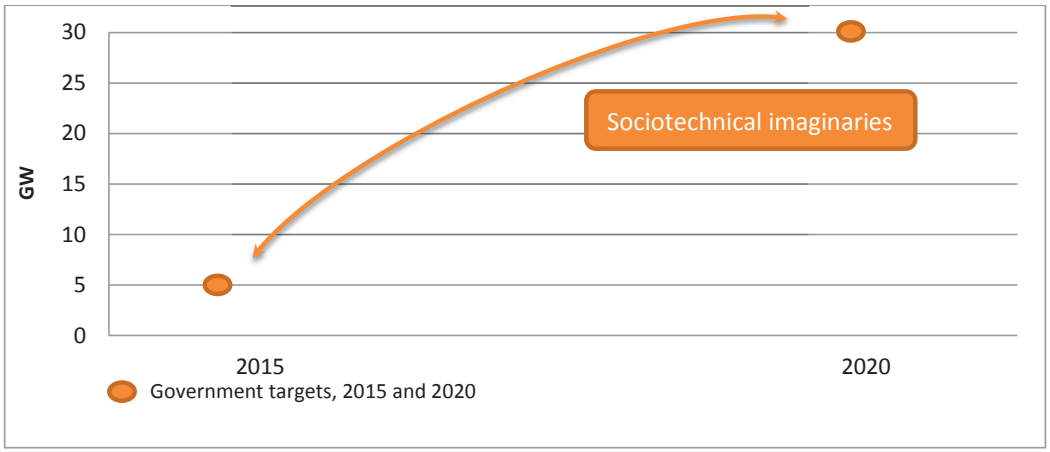

Figure 2: Official government targets in 2015 and 2020 in gigawatts (GW)

By comparing both figures we see that the ambitiousness of the official government targets was not reflected in any of the projections from stakeholders, be they from industry, the government or consultancy agencies. Interviews with policymakers and government agencies indicated that the expectations of the central government with respect to reaching the 2015 and 2020 targets were low. One policy advisor noted that the 2015 development target had been changed from 5 GW (5,000 MW) of 'installed' capacity to 5 GW of projects 'under construction', reflecting a central government acknowledgement that the goals may not be reached. The new wording gave a much broader time span for the actual completion of projects, as the term 'under construction' was not defined and a project could therefore potentially continue for several years into the future.

Target achievements generally appeared to be much 'looser' than what was common in Europe. An official from the Jiangsu provincial government renewable energy industry association emphasised the difference from Europe in this respect:

> In China we use a different way to calculate. Here, once we start construction we calculate it as part of a completed target. So it's not like abroad, usually they calculate from when the installed turbine starts generation, and then they include it as part of the completed target.

In practice, this means that if a project of 200 MW had only one turbine of 5 MW, the whole project counted as part of the achievement. This speaks to the importance of *reaching* targets, irrespective of whether or not the *actual* achievement was reflected in reality. This was also emphasised by many of the interviewees when asked if they believed the 2015

development target would be met. A manager from a foundation manufacturer put it quite bluntly:

> I don't think they will reach it. If it is reached, then it's bullshit. Possibly the [government] officials will do some statistics work and say 'Oh, we reached it!' They will solve it in a very political way. That's how it is here in China, you know, no one wants to get hurt.

Striving to reach goals in themselves was perhaps part of the Chinese culture of avoiding loss of face – something the above interviewee referred to in the phrase 'no one wants to get hurt'. Several other interviewees agreed. As one coating producer put it: 'The Chinese government always reaches what they planned first whether it's a reasonable scientific way or not.' Industry participants were therefore quite aware that government-stated achievements needed to be confirmed by other industry participants.

It is also interesting to note from Figure 1 that industry analysts had higher projections than did other stakeholders. This fits with Williams and Pollock's (2010) notion of promissory agents, wherein industry analysts assume a proactive role and work to make their predictions happen. Nevertheless, the industry analysts interviewed in China were largely struggling to gain an overview of the situation at hand. They were constantly assessing what had actually been done, what was under construction, what orders had been made, what was only at the planning stage and so on. One Chinese consultant at a European certification company emphasised that it was important to constantly communicate with the various stakeholders in order to manage their expectations:

> All the international companies have the same questions. For example you receive the list from the offshore event organisation, that some projects will be kicked off next year. And at the workshop I talked with the director of [a design company] the whole evening. We discussed 'which project can be kicked off, and also which developer'. We really went into detail. Each and every project has its reasons why they can kick off or not. Of course three years or maybe only three months later this will change. So basically you know that you should not really think that 'Oh it's really good, we have 10 projects to be kicked off and we can make our budget based on that!' There will be trouble for everyone if that happens.

This quote shows that the future professed by the government was checked and balanced against the reality of other industry participants, who felt it was important for them not to base their expectations on incorrect assumptions. Since it was difficult to know what and when things would happen, industry participants needed to exchange information. The list mentioned in the above quote was published by the government and outlined the projects

that would be launched at what time. However, the timeline described in the list was much more ambitious than what actually occurred. Knowing that government officials were less ambitious than their targets would suggest, we may say that the government's ambitious prospects created the impression that more was happening and thus allowed government officials to save face regarding the official development targets. Moreover, the ambitious targets made the industry think that things looked promising, and therefore generated more interest.

From the above, we see that the Chinese government consistently overestimated the future; this might have been a strategic decision. However, industry participants were aware of the government's overestimations, and the strategic games observed here may have worked differently than suggested by Geels and Smit (2000). In effect, offshore wind industry participants in China referred to the industry as an unrealised idea that was very likely to happen. As one manager of a certification company put it: 'Currently the Chinese offshore industry is like a cake. So far it's a really beautiful picture, but there is no real cake here. So everybody thinks "I have to be involved or can take some share of it".' The high expectations made the Chinese industry an attractive cake from which many wanted a slice. However, as the manager pointed out, there was no real cake to eat. Nevertheless, even though most industry actors agreed that the 2015 target would not be reached, they were certain that the industry would take off at one point, and at that time, they needed to be in the right position to get a share of the cake. Therefore, the ambitious government targets can be described as part of a promise and requirement cycle that spurred continued action (van Lente, 2000).

We may summarise that government support was negotiated at a local level and assessed in relation to what happened in terms of actual project starts and deliveries. The government targets may therefore be considered constitutive of sociotechnical imaginaries, as defined by Jasanoff and Kim (2009), but this constitution was always locally negotiated. Futures were constructed not only based on the government's high promises, but also on the local expectations of industry participants. Next, I shall proceed to examine the way in which expectations and visions were generated and negotiated by the government and industry actors in China's offshore wind industry.

5. How expectations were generated and situated

It became apparent during the fieldwork that the way in which people talked about offshore wind power was anchored in two main experiences: the existing *European* offshore wind industry and the domestic *onshore* wind industry. These two experiences were typically referred to in assessments of the speed and quality of the development of China's offshore wind industry. Europe frequently served as a basis for comparison regarding the quality of performance in China. This was, for instance, evident in a discussion of the tendering process for offshore wind projects with the Chinese employee of a European certification company:

> The Chinese tenders are not serious. In Europe, everything is prepared well, before a bid is made. But if you do that here, you lose! Sometimes the winner is already decided by the government. You can tell this if you read the tender documents; you can already know who they want to win the tender.

Implied here is that the tender that was held for offshore wind projects in 2010 preceded sufficient preparatory work to ensure the feasibility of the projects. This was apparent even to the developers bidding on the projects. In fact, one larger developer justified the low bid prices and, hence, the low probability of starting the project, by saying: 'If you jump from the 25th and the 20th floor it's the same, you are dead anyways.' In Europe, on the other hand, these tenders would have been organised differently, often supervised by a certification or advisory company to ensure that potential pitfalls were accounted for.

When thinking of the *speed* of offshore wind development in China, interviewees particularly looked to the development of the onshore wind industry. One the one hand, some interviewees hoped that the development of the offshore wind industry would not be as fast as that of the onshore wind industry; on the other hand, they were expecting it to develop with the same swiftness. A Chinese interviewee of the European certification company compared the development of the offshore and onshore wind industries in China, stating:

> I hope the government will take it slowly this time, as opposed to what happened in the onshore wind development, which developed far too fast. It was five, six years of dramatically rapid growth without control. And all the quality issues and everything happened because of that. So I believe the government needs to learn from onshore. The problem here in China is that when the top decides, it will have to happen. And they in turn put pressure down to the developer, and to the industry. That's a kind of dilemma. Personally I would think a time-horizon of 20 to 30 years would be good

> [for the industry development]. This way I can keep my job for a longer time [laughter].

We see that the onshore industry was used as a base for comparison, with the conclusion that *this time*, with the offshore wind industry, it would be better to take it slow. This concern over developing the offshore wind industry too quickly recurred in several interviews. For instance, a manager from a large wind turbine manufacturer thought that: 'The government has observed some problems from the onshore industry, and now they will be more careful. The onshore industry was really booming, but the government has learned, step-by-step.' Again, we see that the government was perceived as the main actor for deciding the speed at which the industry would develop, and industry actors merely followed the tune of the government. Interviewees typically referred to concrete examples of companies that had developed too quickly, had overexpanded and were subsequently on the verge of bankruptcy. One such company was Sinovel, the largest onshore and offshore wind turbine manufacturer. As a Chinese manager of Siemens stated: 'Sinovel only focused on expanding their capacity, expanding their market share and did not think about quality that much. Today the situation is really bad there, and most of their employees are really frustrated.' Interviewees hoped that a greater focus on quality would be prioritised in the offshore wind industry. Hence, industry stakeholders constructed their own likely futures of offshore wind development based on their awareness of the pitfalls that had occurred in the onshore industry.

Some interviewees did not necessarily view the rapid development of the onshore industry as a learning experience that would slow the development of offshore wind energy. Rather, they assumed that the offshore wind industry would follow the same growth pattern. A spokesperson from a large developer said that they 'have an impression recently that the government wants to develop this industry fast. And we can use onshore as an example: after the onshore feed-in tariff was set the industry developed quite fast.' There were also other examples of people expecting the development to happen quickly, as had happened in the onshore industry. An interviewee from a coating manufacturer expected things to 'go crazy' because of what had happened with the onshore industry:

> Interviewer: How fast do you think the offshore wind industry will develop in the next five or ten years?
> Interviewee: I don't know. It's usually quite crazy here. When it starts it just goes crazy. You know during 2011 we were really astonished about the speed of the onshore wind development. The amount of new projects… it was just tremendous.

Another interviewee from a wind farm developer thought that the offshore wind industry would 'copy the mode of the onshore industry'. He added that, over the next couple of years, a lot of companies would enter the industry: 'When everything goes well everybody want to join together.' For these reasons, we may say that onshore wind experiences calibrated visions for the offshore industry, in the sense that the growth could be very quick, and, on the other hand, rapid growth could cause serious costs in terms of low performance, which had been well documented in relation to the onshore wind industry (e.g. Gosens and Lu, 2013, 2014).

Other interviewees were generally sceptical that the industry would develop quickly, simply because there were still too many obstacles for the offshore projects, and onshore resources were still abundant. In this way, the onshore wind experience became a competing expectation for the immediate future. As a government policymaker put it:

> Interviewer: How do you think the offshore wind industry will develop in the future?
> Interviewee: I don't think it will be quick. So far it is inland, and not offshore wind (that has been fast). Because there are many, many things that should be done if you go to offshore wind. Seabed, resource assessments, and also dealing with the different groups, such as the fish industry, the ocean administration, and other coordinators. Yes, many things. So I don't think it will happen in the future three to five years. But for onshore, we already have done a lot of detailed work.

A main focus of the vision of offshore projects was the inland area, often referred to as the 'low wind speed' area that would be developed next. An analyst from the China General Certification Agency put it this way:

> I know from the National Energy Administration that they would like to have more wind energy in the south. I mean, what's left to build out onshore has lower wind speeds than offshore, and for maybe the next two or three years people will still focus on these wind areas and not on offshore.

Several interviewees agreed on this, and a professor from a high-standing university conducting research on offshore wind in China said that 'right now the most valuable resource is the low-speed wind onshore resource, and this is where the government and the industry are focusing right now'. The low wind speed areas were not the only future competitors. Local governments, consistently concerned about economic growth in their areas, had other potential uses for their coastlines. For example, a manager from a foundation manufacturer explained that the local government around Binhai, where one of the concession projects was located, was against the offshore wind projects:

> The Binhai new district expected to develop their shipping business there, and the accompanying logistics, and real estate, and also fishing. So obviously the offshore wind development will contribute negatively to this kind of plans.

As we can see from this quote, the various actors envisaged different futures. These future visions were important in mediating the official government development target, or sociotechnical imaginary, to bring it more in line with local expectations.

The comparison with Europe was also used as an argument for inland wind resources. In Europe, it was claimed, offshore wind was necessary because of land constraints; however, this was not the case in China. This was, for instance, argued by a high-standing government policymaker:

> This is the different situation here with Denmark, Germany and the UK: In Europe the inland almost does not have any more space for wind, but that's different in China. In the future we must use the ocean, but for now we still have some work to do [onshore].

The development of offshore wind was therefore not seen as pressing, and, according to the above interviewee's own estimates, offshore wind would become more important in perhaps 'five or even ten years'. However, another participant from a large developer said that the reason offshore wind energy was preferable was precisely because there was too much land in China, and the distance between people was too great:

> In China it's not like we don't have land anymore, like in Europe. I mean, in Inner Mongolia there is a lot of land, but the problem is that the distances are too great there to the load centres, after the electricity is generated. In the southeast of China, like the Jiangsu, Zhejiang and Fujian, they are very industrially developed areas, and when we generate electricity there it is much easier to transport it. And also the wind resource offshore is better than onshore. So after some testing we think that we can produce some profit from the offshore wind industry.

Interestingly, we again observe that the same conditions were used in two diverging arguments. Above we saw how the onshore wind industry created diverging expectations for the offshore industry. Here, on the one hand, we see that Europe's *lack* of land was seen as the reason why offshore wind became important there, and, on the other hand, China's *abundance* of land (i.e. the great distances between the onshore wind resource and the load centres) was the reason why offshore wind was deemed necessary.

Although it appears as though the industry stakeholders did not completely agree on the importance of either the onshore industry or the European industry for China's offshore

wind industry, we may conclude that they drew heavily on previous experiences in order to adjust their expectations of the future. Indeed, actors drew on examples that supported their construction of the future: different actors had diverging intentions of how the future should look. This interpretive flexibility, noted elsewhere amongst others by Berkhout (2006), made people draw on experiences depending on their future interest. As we have seen, some wanted to keep their job longer, others wanted to make sure that they did not lose face and still others focused on ensuring high-quality products. The bottom line is that the different stakeholders used prior experience to tune their expectations in a desired direction according to their situation and the likelihood of achievement. The effects of these expectations therefore depended on the relation between the future and the actor 'reading' the future in question. In this sense, the sociotechnical imaginary was also impacted, and the government had to alter its development targets, as explained in the previous section. This is examined further as we go on to explore the dynamics between the government targets and the actual industry development.

6. Strategically waiting for the future

In the previous sections, we saw how some interviewees used onshore wind industry experience as an example of why the offshore wind industry *should* develop slowly, and others used the same experience to explain why it *could* happen quickly. Industry and government stakeholders alike expressed an interest in learning from the past, but were prepared for a potentially rapid take-off for offshore wind, as well. Knowing that loss of face was a genuine concern in China, we may ask why the government set such high targets in the first place. Moreover, how did industry participants cope with these large uncertainties? In other words, exactly how did the aforementioned strategic games between the government and industry actors play out?

To start with the first question, Chinese government officials tended to look many years into the future when formulating their vision. This was explained by a high-standing government official:

> We focus on the future, to 2050, so you know all these pollution issues you cannot change in one day, or one year. You must take a long time. You should be clear that by 2050, in 40 or 50 years, what is your challenge, your situation? So, if we are clear about the future, everybody can reach a common idea. Now, we come back, from

> now we should do some work. We must do some work. Otherwise, the future will not wait to come.

We see quite clearly here how the future was enacted in the present, and how the government was convinced that ambitious action was required 'today'. These considerations were manifested in the sociotechnical imaginary envisaged by the government. It was, furthermore, not given that the ambitious government targets would not be met. As reflected in the interviews and industry reports, the most common reason why things did not develop as quickly as expected was the disagreement between the two departments responsible for offshore wind development: the National Energy Agency (NEA), and the State Oceanic Administration (SOA) (Guo, 2013; Korsnes, 2014a; Quartz+Co, 2013). This disagreement resided mainly in the procedures of project approval and project siting. Indeed, the necessary governing mechanisms were not in place to accommodate the government targets. As a turbine manufacturer said in 2013:

> Two years ago the government themselves didn't know how to approve the offshore projects. They didn't know how to do environment assessment for offshore, or what kinds of feasibility studies were needed. I have to say they are still learning.

A project developer agreed with this statement, adding that 'the procedures were not in place to support this kind of projects, so they had to discuss this with other national departments to develop the policies'. The central government needed to establish the procedures for project development, and looking further into the future and setting ambitious targets allowed them to quickly mobilise and coordinate actors internally as well as externally.

Turning to the industry, most actors were waiting for the government to introduce an acceptable electricity price (feed-in tariff) so that offshore wind projects would pay off (Yang, 2014). All of the developers of offshore wind projects were state-owned companies, and were therefore motivated to reach the development targets. However, as they did not receive funding for this, they had to use money from their internal budget. This was explained by a manager from one of the largest developers:

> We cooperate with the NEA [National Energy Administration], but actually we are the ones who pay for [a demo project close to Shanghai]. We proposed the project to the NEA, and they approved it, so in terms of technology support, opportunities and policies we got a lot of benefits from the government.

In other words, the NEA supported the company in a non-financial way, but the company had to pay for the actual development. In this way, the government was able to ensure that prices were not unrealistically high. Moreover, it was clear that the government depended on the industry to make the initiative and start development. The industry actors were also aware of this, and used it to gain increased support from the government, when needed. This was particularly clear with the four so-called concession projects, totalling 1,000 MW, that were initiated in 2010 but had not yet started construction in 2014. The official from the Jiangsu provincial government renewable energy industry association explained the situation:

> The reasons the government gives to the public of why the projects have been postponed is because of the disagreements between government agencies. But those are just public reasons. The real reasons, actually, I have met with all the related companies for these four concession projects last week, and they say that the main reason is because of the technology. They do not think the technology is mature yet, and the cost is very high.

In other words, the developers did not start constructing the projects because they were too expensive, and they were waiting for the government to increase funding.

But who is the 'government' in this respect? As it turned out, few appeared to know exactly who the decisive actors were. This uncertainty with respect to the government was prevalent in much of the interview feedback, for instance in that of an employee of a government-organised renewable energy industry association that was quite close to the politicians making decisions, and which informed the government of policies to be implemented. Asked when she believed the top-level government would start developing offshore wind projects, she answered that 'no one really knows these things'. Only a few selected individuals knew about the 'top-level' plans. An energy consultant who had been working with wind energy in China since 2002 made a similar point. In 2011 he said the following when asked how policy had been set for the wind industry in China:

> A lot of these things are run by the ERI [Energy Research Institute] and people in the wind energy association, or the renewable energy association. These people often have dual roles, they're either professors or industry association people and they are relied on to advice the NEA [National Energy Administration], and write draft policies. The problem is you never know who has the final word. I mean the academics draft the stuff and then politically it is expedient. But does it happen or does some big guy just walk in the room and say, "No, it has got to be this way"? Nobody knows.

Industry actors were therefore in the dark as to exactly what would happen, and when. Everyone apparently was prepared to 'jump the train', as the government had announced ambitious development targets, but few knew exactly when the train would depart and in what direction it would head. Thus, the government remained obscure, and industry actors had the impression that things could change at any moment. This uncertainty impacted expectations in that people needed to be open for both rapid change and no change. Small offices could grow large literally overnight, but could also stay small. The government remained obscure because it needed to sort out the internal organisation of projects. But the mysteriousness kept industry actors alert and ready to make a move when the signal was right. Industry participants needed patience, and they needed to believe that something would happen at one point in the future.

The quintessence of the strategic games was caused by conflicting expectations: the government could, at any point, introduce a feed-in tariff, and companies who wanted a piece of the cake had to be prepared to jump the hoop. It became a strategic waiting game – a waiting game that was characterised by ambitious government intentions but ambiguous signals in terms of implementation. It was, however, not a waiting game of 'wait and see', but rather 'wait and prepare'. Thus, the character of the game was different from the way in which it was portrayed by other empirical examples and in the expectations literature (e.g. Geels and Smit, 2000). Interviewees from Chinese industry appeared to have a reflexive attitude to government images: they knew that something would happen, just not when. The performativity of expectations was not located in the circulation of expectations as such, but rather expectations about the performativity of imaginaries.

Following this line of reasoning, we arrive at a new interpretation of the ambitious government targets. The government depended on industry input in order to develop procedures, assess costs and get things done. Industry actors, however, did not accept the validity of the vision in entirety, and were able to convey their version of what was possible and affordable. The government then modified its targets accordingly, for instance by changing from 'installed capacity' to 'under construction', or in actually reducing the targets (Smith 2014). We can therefore claim that the government used sociotechnical imaginaries as planning tools – a litmus test of what was feasible – and incorporated industry feedback as an important measure to achieve its intended futures. In this way, the coproduction of imaginaries and expectations differed radically from the theory: we are not only talking

about creating a protected space (Geels and Smit, 2000) or about norms for nationhood (Jasanoff and Kim, 2009), but about plans to be manifested. Ambitions shaped the road ahead and ambiguity became a space for negotiation – a necessary reality check for plan-fixated technocrats and cost-concerned companies.

7. Conclusion: Ambitious yet ambiguous futures

This paper has examined the role of imaginaries and expectations in China's offshore wind industry in order to better understand the role they play in the early phases of technology development. In particular, this paper has looked at how sociotechnical imaginaries were negotiated by local expectations, how expectations were generated from experiences with the onshore wind industry and Europe's offshore wind industry and how strategic waiting games characterised industry development. The paper first showed the way in which government targets were set and later negotiated between the government and industry. Given that the early developments of the onshore wind industry continually missed development targets, there is a fairly strong indication that development targets were set rather ambitiously in China. This ambitiousness generated a spur of interest in the industry and government, pushing policymakers to move the issue up the agenda. In this way, a promise and requirement cycle, as van Lente (2000) describes, was generated, and industry participants expected the government to follow through with support schemes for developing the industry.

In general, the basic tenets of the sociology of expectations appear to resonate well with the Chinese offshore wind industry with regards to promise and requirement cycles and strategic games between technology spokespeople and others. However, the interaction between government-induced sociotechnical imaginaries and industry expectations provides some new perspectives on the way in which nation-specific and industry-specific expectations can merge into quite concrete actions and plans. By describing a strategic waiting game between the government and industry actors, the analysis has emphasised the fact that companies had to be prepared for both change and inertia. In China, companies and politicians were future-orientated and looked at what the various long-term plans had in store for them. Things could change quickly from one day to the next. Companies therefore had to be prepared to be taken by surprise.

I identified two characteristic components of the waiting game: First, companies delegated responsibility for their future activity to 'the government' and waited for its call. Second, the government remained obscure and ambiguous, leaving industry participants on their toes as to what would happen next. More importantly, however, keeping the future ambitious but the implementation ambiguous appeared to be a strategy employed by the government to ensure change without detailing the road ahead. In this way, the government-induced sociotechnical imaginary was employed as an important planning tool that helped to calibrate industry development.

The paper has established that the government played an important role in constructing successful visions in China. By making a novel nuance between expectations and imaginaries, this paper has contributed to a better understanding of the dynamics of expectations and their constitutive force in China: as industry actors typically expected something to happen, the negotiation centred on *the extent to which* government imaginaries could and should be performative. Expectations in China materialised more concretely than indicated by both the sociotechnical imaginaries approach (Jasanoff and Kim, 2009) and the sociology of expectations (Borup et al., 2006). We may ask whether we can define a sociology of expectations that is unique to China: a 'sociology of future governance'. With a plan-based economic history, China's visions were bordering on loose plans, and the dynamic between imaginaries and expectations could be characterised as a planning tool the government made efficient use of in order to calibrate plans for the future. Government targets that 'failed' to be reached were therefore not failures per se, but important indicators that were used to calibrate new targets.

In practical terms, the described dynamics of future-orientation in China have several implications. For instance, the waiting game appeared to be biased towards larger companies that had the means to keep large capacities idle over time and could jump the train when it started. In China, this typically included the large state-owned enterprises. The waiting game could therefore be used strategically to ensure domestic (state-owned) companies gained a larger market share than did other (private or foreign) companies. In effect, the waiting game can be seen as a protective mechanism that may have given domestic companies a buffer zone to help them acquire the technologies of frontier companies. Another implication is that, as these concrete expectations were negotiated and manifested, the initial imaginary set by the government had a big impact in terms of the

direction in which the industry developed in China. Had the Chinese Communist Party not had a wish to develop renewable energy technologies in the first place, nothing would have developed. In a sense, the concreteness of expectations in China rests on the legitimacy of previously fulfilled expectations in other industries. Ironically, therefore, the success of Chinese companies in developing coal power industries, for example, may be the reason why expectations are so high for China's offshore wind industry, today.

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