AESC Working Paper 1

Collaborative governance for sustainable development: a comparative study of wind resource assessment in Xinjiang and Guangdong Provinces, PRC

Daphne Ngar-Yin Mah[1] and Peter Hills[2]

Publication Date: Nov 2014
Original Publication date: Oct 2009

[1] Director and Assistant Professor, Asian Energy Studies Centre and Department of Geography, Hong Kong Baptist University
[2] Chair Professor, The Kadoorie Institute, The University of Hong Kong; Fellow, Asian Energy Studies Centre, Hong Kong Baptist University

This paper is work-in-progress and the authors welcome constructive feedback.
The paper should not be quoted without the permission of the authors.
Correspondence to lead author: daphnemah@hkbu.edu.hk

Abstract

This paper focuses on collaborative governance for sustainable development in the context of wind resource assessment (WRA) in China. Renewable energy, including wind energy, has become one of the key energy options which will assist China in meeting its rapidly growing demand for energy as well as its sustainability goals. However, wind energy remains a fringe source in relation to China's coal-dominated energy system. WRA has been identified as a key impediment to the further development of this energy source.

With its emphasis on a multi-actor, bottom-up approach, collaborative governance has become one of the key public policy strategies adopted in both developed and developing countries. This paper examines whether collaborative governance can help to improve WRA in China, and if so, through what mechanisms.

The paper proceeds by comparing collaborative initiatives involving WRA in two Chinese provinces, Xinjiang and Guangdong. It suggests that while the central government has an important role to play, there are many opportunities for locally-based collaborative initiatives to serve as an alternative, complementary approach to facilitate WRA. There are important contextual elements such as local resources (including leadership and local knowledge), and governance structures (such as social ties) that can facilitate such initiatives. The paper concludes that a broader perspective that places more emphasis *beyond the centre* in capacity building for WRA is required to enhance the prospects for a transition to a more sustainable energy system in China.

Key words: China, wind energy, wind resource assessment, sustainable energy, collaboration, governance

1. **Introduction**

Renewable energy, including wind energy, although capable of making a significant contribution to sustainable development has yet to reach its full potential in either developed and developing countries (Jefferson, 2008). The gaps in current knowledge about how and why the concept of sustainable development is difficult to implement remain, and particularly so in the context of China. In an attempt to fill some of these knowledge gaps, our paper draws on the linkages between the theoretical concept of collaborative governance and the empirical development of WRA in two Chinese provinces, Xinjiang and Guangdong.

Wind energy has been regarded as one of the key energy options for achieving sustainability goals in both developed and developing countries (WWEA, 2009). China has also joined the global trend of accelerating its investment in wind energy. China's coal-dominated energy system and energy consumption patterns are unsustainable, leading to major issues of energy security, climate change impacts, environmental degradation and social instability (Economy, 2007; MIT, 2007; Pozon and Mench, 2007). Wind energy is seen as one of the key components of China's sustainable future not only because it is renewable, clean, indigenous and abundant, but also because of its many other advantages. It has the potential to become a mainstream, rather than merely a supplementary, energy source (DOE, 2008). It is relatively cost-competitive with conventional technology (IEA, 2007). Experiences in the west have also demonstrated that this hi-tech industry has the potential to generate green jobs and to revive local economies (BMU, 2007; DOE, 2008). Furthermore, wind energy also has an important role to play in rural electrification (GWEC, 2009b; NREL, 2004a, 2004b; Wang *et al*., 2006).

Following the enactment of China's Renewable Energy Law in 2005 and the introduction of a number of important supportive policies that now cover pricing, technology, grid access and other policy domains, wind energy installations have increased at an exponential rate in recent years. The installed capacity of wind energy in China doubled each year from 2004 to 2008, and had reached 12.8 GW by the end of 2008 (CHECC, 2008; EF, 2009; Martinot and Li, 2007). China now ranks fourth in the world in terms of the number of wind installations (GWEC, 2009a).

Although promising, the outlook for wind energy in China is clouded by various factors. Wind is still a fringe energy source contributing only 0.16 percent of the country's total electricity generation and 0.78 percent of the total installed capacity (end 2007) (SERC, 2009).

Although wind energy does not require fuel, wind resources vary over time and location (Reeves, 2003). A good understanding and estimation of wind resources is therefore essential to many important aspects of the development process, from energy planning to site planning and the predictions of the economic viability and financial risks of potential wind farm projects (Singh *et al*., 2006). However, wind resource assessment (WRA) is a difficult process that demands good siting of anemometer towers, appropriate choice of measurement techniques, trained staff, quality equipment and thorough data analysis techniques (NERL, 1997).

The lack of high-quality WRA has been identified as one of the major barriers to the further development of wind energy in China. For decision-makers, the data are currently too sparse to set wind targets at either the national or provincial levels in an evidence-based decision-making manner. For potential wind farm developers, the data also fail to provide a good understanding of the characteristics of wind resources for micro-siting of potential wind farms (Interview BJ/01/2005). As such, if wind energy is to contribute more than a few percent points of China's total electricity demand, high-quality WRA is necessary.

Collaborative governance has grown in importance as a strategy for achieving sustainability goals in part due to its multi-sector and bottom-up approach to problem-solving. Understanding whether collaborative governance can strengthen the capacity of China in the task of WRA is therefore of importance to scholars and policy-makers. This paper aims to apply the concept of collaborative governance to guide our examination of the development of WRA in two Chinese provinces, Xinjiang and Guangdong. Specifically, we discuss whether collaborative governance facilitates the WRA, and if so, through what mechanisms.

This study adopts a comparative case-study methodology to examine the process of collaborative governance for the sustainability transition in China. A case-study approach is well suited to provide answers to "how" and "why" questions (Yin, 2003), and is therefore a useful research methodology to understand how and why collaborative governance works or does not work in Chinese provinces in the context of wind resource assessment.

The case studies presented here draw on data and information derived from desktop research, site visits and interviews with prominent stakeholders. Face-to-face interviews were conducted in Beijing, Xinjiang and Guangdong between 2005 and 2008. Interviews were conducted with government officials, senior executives from energy utilities, wind farm developers, wind turbine manufacturers, academics, NGOs, industrial associations and consultants.

2. Collaborative governance and WRA

Collaborative governance: a normative perspective

Collaborative governance has received growing interest from scholars and policy-makers as an innovative strategy to respond to many different types of problems in contemporary societies (Huxham and Vangen, 2005). Studies on collaborative governance have been undertaken across a wide spectrum of major public policy domains, from environment (de Bruijn and Hofman, 2002; Hartman *et al*., 2002) to public health (Roussos and Fawcett, 2000), and housing (Boyle, 1989).

Collaborative governance, which is defined as a governing arrangement where public agencies engage non-state stakeholders with the aim of making or implementing public policy or managing public assets (Ansell and Gash, 2008), has its roots in the theoretical perspective of governance. The central theoretical insight of the governance perspective is the shift from government to governance. In view of the traditional state's limits to cope with social problems, governing needs to move away from a reliance on the mere capacity of the formal state apparatus to a policy-making system that is more decentralized, more flexible and more inclusive (Fisher, 2006; Hall, 1993).

Specifically, collaborative governance involves a process in which diverse stakeholders are engaged to bring together their individual inputs for collective goals (Cordery, 2004; Hartman *et al*., 2002). The essential features of collaborative governance include: the engagement of a wider spectrum of interdependent actors beyond the state, i.e. including the non-state actors (Ansell and Gash, 2008; Cordery, 2004); a strong emphasis on openness in information sharing, respect for dissenting views, and a commitment to long-term interacting process (Thomson and Perry, 2006); and, in addition to achieving individual ends, there is the achievement of additional, shared benefits (Thomson and Perry, 2006).

What, then, drives people, organisations or governments to enter into collaboration? The literature suggests that as individual efforts have limits in addressing problems, collaboration allows opportunities for cross-sectoral actors to combine complementary resources and expertise (Widdus, 2001). The main benefits of collaboration include creating trusting relationships that are needed to address complex societal problems, achieving efficiency by coordination, and sharing costs or risks (Huxham, 2000).

Collaborative efforts, however, can be jeopardized by different forms of inertia. Institutional inertia and disciplinary inertia, for example, can inhibit cross-sectoral or transdisciplinary collaboration (Rickson *et al.*, 1990). Power imbalances or information asymmetry may also undermine the effectiveness of collaborative efforts during the bargaining process (Huxham and Vangen, 2005; Koontz *et al.*, 2004; Yoder, 1999). Furthermore, consensus decision practices that are central to collaboration can limit opportunities to make bold, innovative policy recommendations. An incremental approach, which may not be sufficiently decisive to meet the needs of the sustainability transition, may instead drive the decision-making process (Koontz *et al.*, 2004; Shirk, 1993; Wright, 2000; Yan, 2001; Yoder, 1999).

Collaborative governance as a framework for understanding WRA

WRA is the statistical analysis of wind power density and wind energy in a given region or location (Mani and Rangarajan, 1996). The critical information is the speed and direction of the wind, its consistency, and the factors influencing wind characteristics at any particular location (Mani and Rangarajan, 1996). WRA is more than a science. The process for WRA, from data collection, to management, analysis, and the use and sharing of wind data can be viewed as a governing process.

Several features of WRA make the concept of collaborative governance a particularly suitable framework to analyse its development in the context of China. WRA exemplifies complexity, enormity and uncertainty in its nature. WRA is complex in nature because it involves different measurement and analysis techniques, and falls into different disciplines and across sectors. For example, wind data can be obtained from in-situ measurement, that is from meteorological masts, or can be retrieved from satellite data (NERL, 1997). Furthermore, wind data may not rest solely in the hands of the state. Wind farm developers and wind turbine manufacturers, for example, may obtain useful wind data from their own wind masts. The complexity of WRA implies that a multi-actor, multi-technique, and transdisciplinary approach is required to do the task more efficiently and effectively.

Effective WRA is also an enormous task. It is a multi-scale and multi-location activity, implying a major investment of time, and financial and human resources. The issue of enormity is of particular concern because WRA at different scales that range from a macro-scale national or regional assessment to a meso-scale and to a site-specific micro-siting one are highly complementary (Hau, 2006; NERL, 1997).

In part because of its complexity and scale, WRA is also a task involving uncertainty. The complex interactions across a wide spectrum of actors make simple, linear models of cause and effect invalid (Voß and Kemp, 2007). Rather, in such uncertain situations, feedback becomes important (Voß and Kemp, 2007). An undesirable implication associated with uncertainty is that actors need to make choices without adequate information to assess, for example, the expected outcomes of a wind farm investment (Haas, 2001).

Understanding the ways in which collaborative governance may influence the ability to accomplish the tasks of WRA in China is therefore an important aspect of a better understanding of the sustainability transition in the country. Literature on collaboration in the context of the sustainability transition of energy systems has been limited, and is particularly so in the context of China. The complex mechanisms of how collaboration works, or does not work, particularly at the local level, need to be explored.

We therefore adopt the concept of collaborative governance as an analytical framework to guide our analysis of WRA initiatives in the two selected provinces (Figure 1). The framework focuses on the key actors' interaction, in what forms (i.e. the models), and what are the conditions that make collaboration work or not work (i.e. the positive and negative conditions), and the outcomes of these collaborative interactions.

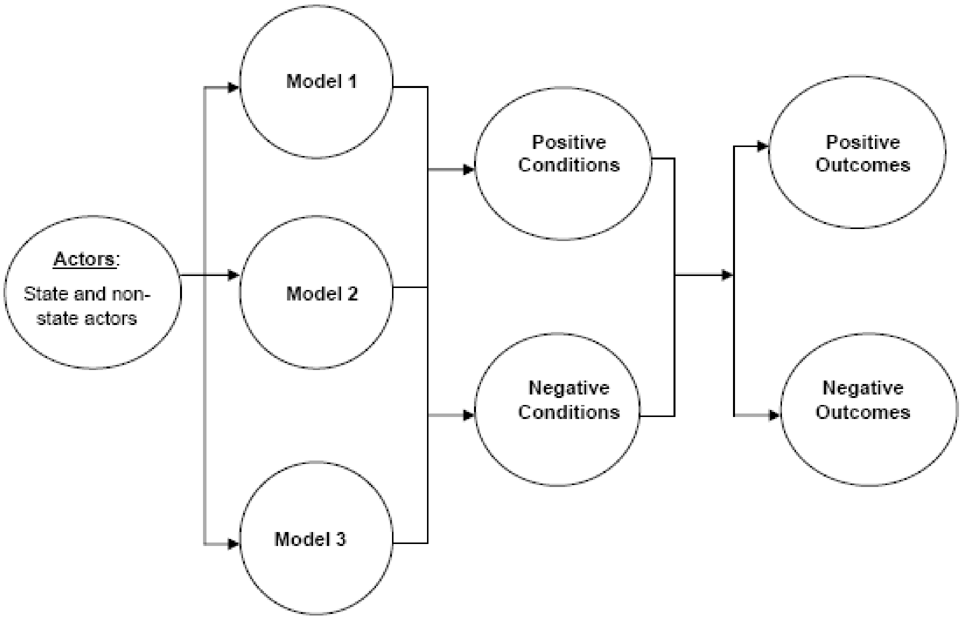

Figure 1: A conceptual framework of collaborative governance

3. WRA in China: overview, features, and key issues

The Chinese government started to undertake WRA in the 1970s. Three national wind resource surveys were completed in the 1970s, the late 1980s, and 2006 respectively. The third national survey concluded that China's total wind resources is more than 10,000 GW, with 430 GW onshore, and 700 GW offshore (CRESP, 2006, 2008a). To date, the Chinese government has produced national wind resource maps with mean annual wind speeds using data from over 2,500 meteorological stations across China (Interview BJ/02/2006).

As China has committed itself to increasing wind energy (Martinot and Li, 2007), the government established the Center for Wind and Solar Energy Resources Assessment under the China Meteorology Administration (CMA) in 2006 (CCChina, 2006). The establishment of the Centre is a major institutional development to strengthen the capacity of the government in WRA.

Under the leadership of the NDRC and Ministry of Finance, the CMA started the fourth major national WRA initiative in 2007. This is officially called the Wind Resource

Detailed Survey and Evaluation Project (风能资源详查和评价项目 *fengneng ziyuan xiangcha he pingjia xiangmu*), with funding of approximately 200 million yuan from the central government (CMA, 2009a). This initiative aims to establish a national network of wind monitoring stations consisting of 400 anemometer towers, ranging from 70 to 100 meters in height to collect data (CMA, 2009; Interview BJ/02/2006). By July 2009, 393 anemometer towers had already been built in 28 provinces (Wang and Hu, 2009). The fourth national WRA initiative is one that has been undertaken by the central government to establish a centralized infrastructure to facilitate the collection, management, analysis, use and sharing of wind data, and to use the database to generate a national wind atlas. The atlas is expected to include extreme weather and offshore wind conditions. However this is by no means an easy task to accomplish as the CMA in general has suffered from a lack of skilled personnel in its 50,000-member staff (NDRC, undated a, b). There are also problems of high-level coordination.

WRA in China is largely managed in a state-directed, top-down, hierarchical manner. The national wind resource surveys have been conducted by the central government at the national level with the key responsible agencies including the then National Meteorology Bureau and its successor, the CMA. The active involvement of the National Development and Reform Commission and the Ministry of Finance in the on-going fourth national survey reflects attempts to introduce new institutional arrangements at the top central level to strengthen China's capacity to undertake WRA. The national surveys used data supplied by the extensive network of sub-national meteorological bureaus across China (CMA, 2009b).

While the state has a pivotal role in WRA, there has also been collaboration between the state and external parties including international organizations, internationally recognised consultancy firms (such as Garrad Hassan) and other countries (Badger, 2009; CRESP, 2008; Martinot and Wallace, 2003; Wallace *et al.*, 2006). However, such collaboration with actors outside the state apparatus has remained peripheral.

Independent institutions providing professional WRA, although common in many developed countries, have not been active in China. In-house WRAs conducted by the wind farm developers themselves are however more common.

Despite the state-led model for WRA which has made some significant progress over the years, several key issues remain unresolved. These are:

(a) Inaccuracies in data:

While it is commonly believed that the national wind resource surveys have underestimated wind resources in China, there are cases of individual wind farms where the micro-siting assessment has over-estimated the resources available. A wind farm in Guangdong, for example, has reported a 30 percent discrepancy between the projected and actual energy yield (Interview GD/05/2008). Inaccuracies in the estimation of wind resources in China can be attributed to two reasons. First, the Chinese national surveys used data from meteorological stations which monitored wind data at a standard height of 10 meters. These official surveys therefore tend to underestimate the wind resource because rotor hub heights are usually between 80 and 100 meters and wind speed typically increases with height above ground (Hau, 2006; Reeves, 2003). Second, the meteorological masts are usually located far from the potential wind-farm sites as these locations were chosen for the purpose of weather forecasting rather than specifically for WRA (Interview BJ/02/2006).

The accuracy of WRA is a major issue for the future development of wind energy in China because the energy potential of wind is proportional to the wind speed cubed (Christiansen *et al.*, 2006). An underestimated wind resource would tend to result in output targets that are too low. The findings of the third national wind resource survey, which is widely regarded to have under-estimated China's wind resources, have been used as a key reference in wind energy planning at the provincial level (QXB, 2009). As a result, the national and provincial wind energy plans or the more specific siting plans are made in the absence of high-quality WRA, and the provincial wind energy targets, and the associated national target, are widely regarded to be too low.

(b) Tardiness in responding to the needs for WRA

State-directed efforts in WRA have revealed a number of problems, including the lack of continuous assessment and evaluation of data, relatively slow work progress, and tardiness in responding to new needs. The first and second national wind resource surveys were conducted in the 1970s and 1990s respectively (Interview BJ/02/2006). The time lag of almost two decades between the two indicates the lack of continuous assessment of wind resources. Progress with the on-going fourth national WRA initiative has been relatively slow, partly because high-level coordination across the central agencies tends to be time-consuming. Furthermore, the recent trend of exploring offshore energy potential has created new demands for wind resource mapping over the sea, and has posed additional challenges to the existing WRA management system.

(c) Resources outside the state remained largely untapped

While meteorological stations across China have provided useful data for the national wind resource surveys, the state system of WRA has limited access to and integration with the vast data system in the private sector. Outside the state system, additional detailed wind measurements have been conducted at specific sites by potential wind farm developers to provide more reliable predictions with which to assess the financial viability of projects. There are about 1,600 such wind monitoring masts across China but as many as 1,500 of them have been built and are owned by enterprises, and only about 100 have been built by the meteorology agencies. The CMA therefore has access to data from only about 100 of those masts, but not the majority of the wind monitoring sites (Interview BJ/02/2006). This situation reflects the fact that there is a clear boundary between the state and the private sector in WRA.

(d) Low public access to information

Although published isopleth maps of wind energy across China are publicly available (Singh *et al*., 2006), there is limited public access to the more detailed wind resource data available in local meteorology bureaus. Wind resource data held by the National Meteorology Bureau and the Meteorology Institute used to be available on a fee basis (Singh *et al*., 2006). Although the data produced by the state agencies are increasingly transparent in recent years as a result of the central policy to enhance information transparency (Interview BJ/02/2006), non-state actors have still experienced limited access to the state-held data. Access to the data is sometimes subject to the discretion of individual local bureaus (Interviews GD/01/2007; GD/02/2006). Wind data from the private sector is usually confidential and is not shared in the public domain.

To conclude, the WRA system in China is characterised by its state-directed, hierarchical manner with a clear boundary between the state and the private sector. There has been involvement of actors outside the state apparatus, but such non-state involvement tends to be ad-hoc in nature, and limited in both scale and continuity. It is interesting to note that resources for the assessments are relatively abundant, in terms of the availability of wind data and funding, in the private sector. Under these circumstances, while the national wind resource surveys are useful for general wind energy appraisal, they have revealed major weaknesses: for the decision-makers, these surveys are too rough to be used to set wind targets at national or provincial levels; for potential wind farm developers, these surveys also fail to address site-specific problems because there is a poor understanding of the characteristics of extreme weather such as typhoons and sand storms and their impacts on turbine performance.

Despite these problems at the national level, locally-based collaborative initiatives have emerged in some Chinese provinces to facilitate WRA. This paper examines collaborative initiatives for WRA in two Chinese provinces, Xinjiang and Guangdong. While the case of Xinjiang highlights the workings of an enterprise-led collaboration, the case of Guangdong examines bottom-up collaborative initiatives between an NGO, a local university and an international consultant. The comparative analysis of the two cases provides a better understanding of the local diversity of collaborative initiatives, how and why collaboration works, and why it does not. It will also illuminate the prospects and limits of collaborative initiatives in the Chinese context.

4. WRA in Chinese provinces

4.1. Xinjiang: an enterprise-led model of collaboration

Located in the far northwest of China and possessing some of the best wind resources in the country, Xinjiang has experienced tremendous progress in the development of wind energy. The total installed capacity of wind energy connected to the grid system in Xinjiang reached about 190 MW by the end of 2007 (Interview XJ/01/2008). This remote province is also renowned for being the home of Danbancheng Wind Farm, one of the largest wind farms in Asia. Goldwind – a leading domestic wind turbine manufacturer in China - is based in Urumqi, the capital of the province (CHECC, 2008).

Like the rest of the country, official wind resource data are limited. However, interestingly, because of the relatively long history of wind farms in the region, the wind resource data held by the wind farm developers are relatively rich (Interview XJ/01/2008). These developers, in particular Xinjiang Wind Energy (XJWind) – one of the pioneering wind farm developers in China - have served as a crucial source of wind resource data from their network of wind resource monitoring masts that spread across the province.

The official estimate of Xinjiang's wind energy resources currently available is based on the findings of the third national wind resource survey completed in 2006. The official estimate, which put Xinjiang's wind resources at 120 GW (Interviews XJ/03/2007, XJ/04/2008), is widely perceived to be an under-estimate. The fourth national wind energy survey is on going but the progress has been relatively slow. By the end of 2008, none of the 17 anemometer towers approved by the CMA had been set up in Xinjiang (Interview XJ/05/2008). It was only in June 2009 that all the towers were finally erected (Lin and Wang, 2009).

It is against this background that in late 2007 the Xinjiang Development and Reform Commission (DRC) initiated a collaborative project with XJWind to conduct a study of local wind resources and wind energy plans. The study was completed a few months later in early 2008.

In contrast to the conventional state-led model of the WRA, the collaboration initiated by the local DRC is significant in various aspects. First, it is characterized by an enterprise-led model. The XJWind demonstrated its central role in accomplishing the task of the WRA. Although XJWind was commissioned by the Xinjiang DRC to carry out this task, this project is collaborative in nature as the local government has not paid the company for the service. XJWind was willing to work with the local DRC on a goodwill basis in the absence of any financial reward. Such a commitment from XJWind was in part a reflection of the company's aspiration to contribute to a better understanding of the wind resource potential in the region. It was also economically feasible for XJWind to do so because many of the data could be derived from their own existing wind energy monitoring masts and therefore involved minimal additional data collection costs.

XJWind was also able to arrange informal deals with other local wind farm developers and with Goldwind for free data-exchange. Such informal deals were made possible largely due to the social networks and trust that XJWind had established with the other local developers over the years. XJWInd is also a share-holder in Goldwind. Some data were also obtained from the Xinjiang Meteorology Bureau free of charge (Interview XJ/05/2008).

The findings of the WRA conducted by XJWind have become useful evidence for the Xinjiang DRC to formulate much more ambitious wind energy plans. In mid 2008, the

Xinjiang DRC submitted a master plan entitled "Medium- and long-term wind energy plan in Xinjiang for the 11th Five Year Plan and by 2020 (新疆"十一五"及 2020 年风电发展规划 *Xinjiang Shiyiwu ji Erlingerlingnian Fengdian Fazhan Guihua*)" and two designated plans for two local wind districts, namely Dabancheng Wind District (达坂城风区 *Dabancheng fengqu*) and Hami Wind District (哈密风区 *Hami fengqu*).

If the new plans are approved, the provincial wind energy target by 2020 would be at least 35 GW. Some 20 GW will come from the two wind districts in Dabancheng and Hami as each of them will develop a 10-GW wind energy base by 2020 (Interviews XJ/02/2008, XJ/05/2008). In contrast, the original wind target set in 2006 at 1.46 GW by 2020 was substantially lower (Interviews XJ/02/2008, XJ/05/2008). In October 2008, the new plans were still pending approval from the central government.

Various advantages derived from this enterprise-led collaboration. Cost-sharing and efficiency were achieved. These have allowed the WRA to be accomplished in an efficient and cost-effective manner, with limited additional costs incurred by the Xinjiang government and the collaborating parties. As a result, the Xinjiang government was able to make evidence-based decisions on its wind energy plans and consequently set much more ambitious wind targets for the future.

How, then, did this collaboration work in the absence of substantial state funding and even though most wind data were not owned by the state but in the hands of the private sector? Several local conditions were found to be crucial in contributing to its success. In terms of local resources, *local leadership* and *local knowledge* were of vital importance. XJWind has long been a local wind energy advocate and its commitment and perseverance in wind energy development in the province partly explained why this collaboration was successful. Moreover, the wind resource data scattered across a number of local wind farm developers was converted into valuable local knowledge once the data set was assembled, synthesized and analysed by XJWind. This pool of local wind data is a valuable complement to the official data. The data are valuable in part because they provide relatively long-term perspectives on the energy yield from the existing wind turbines, and in part because they can better reflect local wind energy characteristics.

In terms of governance structure, the social ties and trust between XJWind and other local wind farm developers, between XJWind and the local government, and between XJWind and Goldwind has facilitated XJWind's access to field data from other local wind farm developers and operators as well as a wind turbine manufacturer. This extensive network has allowed XJWind to reach out and to integrate previously scattered wind resource data and to create new information that can be partially shared in the public domain.

A comparison of the key features of enterprise-led model of WRA in Xinjiang and the state-led models adopted in the third and fourth national wind resource surveys is illustrated in Table 2.

Table 2: A comparison of the state-led and enterprise-led models of wind resources assessment in Xinjiang

	3rd National Wind Resource Survey	4th national WRA initiative (officially called "Wind Resource Detailed Survey and Evaluation Project")	Enterprise-led Xinjiang Wind Resource Study
Progress	Completed in 2005	On-going Started in 2007, but no anemometer towers erected by end 2008. Towers finally all set up by June 2009.	Commissioned in early 2008 Completed in mid 2008
Estimates of wind resource in Xinjiang	120 GW	N.A. yet	Wind is plentiful for a 35 GW wind target by 2020
Key actors	The centre; provincial government	The centre; provincial government	Enterprises; provincial government
Approaches	Top-down administrative management	Top-down administrative management	Horizontal collaboration
Equipments	A total of 106 weather stations across Xinjiang	Instrumentations specialized and standardized for wind resource assessment: 10 anemometer towers with a height of 70 meters; 7 towers at 100 meters	Instrumentations vary in models and quality Integrated use of techniques – including GIS and remote sensing
Strengths	Official data from existing meteorological stations readily available Data sharing among government agencies: some data from the meteorological stations of Xinjiang Production and Construction Corps (XPCC), and railway company	Standardised instrumentation and techniques Wider coverage: in 7 wind districts in Xinjiang An increase in the number of monitoring poles Wind measurement of relatively *long* period	Wind data collected by specialized method Quick delivery of study outputs Integration of data sources: external sources of data include data from other enterprises and some official data Minimal financial burden: social -exchange among enterprises involved ; no commission fee paid
Weaknesses	Equipment not specialized for WRA Only 10 out of the 106 weather stations were located within wind districts At a height-level of 10 meters – tend to underestimate wind resource Minimal data-sharing with non-state actors	Progress relatively slow Approved number of anemometer towers far lower than required by the Xinjiang government (17 towers approved, although applied for 80-100 towers)	Instrumentations not highly standardized Wind measurement of relatively *short* period

(Sources: authors; information from interviews XJ/03/2007, XJ/04/2008, XJ/05/2008)

4.2. Guangdong: a bottom-up, society-university-enterprise collaboration

Guangdong has the longest coastline among China's provinces (Cheung, 2002), providing excellent access to wind energy resources in many coastal areas. By the end of 2007, there were seven wind farms in Guangdong, with a total installed capacity of 278 MW (Energy Office, 2008).

Bottom-up, society-enterprise collaborative initiatives have been relatively active in the area of WRA in Guangdong. A distinctive feature of collaboration in WRA in Guangdong has been the critical role played by a wide range of non-state actors, including Greenpeace China, Garrad Hassan, an international wind energy consultancy firm, Sun Yat-sen University, a local university, and Honghaiwan Wind farm, a local wind farm developer. As such, these collaborative initiatives are distinguished by a strong bottom-up characteristic and involve a wide range of actors that span across the private and societal sectors.

Two major collaborative initiatives for WRA in Guangdong have been identified. The first initiative was initiated and led by Greenpeace China in 2004. Greenpeace China commissioned Garrad Hassan and the Research Centre of Wind Resource under the School of Engineering at Sun Yat-sen University (中山大学工业院风资源研究中心, RCWR) in Guangzhou to conduct a WRA for Guangdong. A major output of the collaboration was the release of a report entitled "Wind Guangdong" in 2005 by Greenpeace China. The report estimated that the wind energy potential in Guangdong is huge and could reach 20 GW – approximately one third of the total installed capacity of the Province's power system in 2007 (Greenpeace, 2005).

This collaboration turned out to be much more than a conventional commissioning experience. It also enabled knowledge transfer and resource pooling between Garrad Hassan and the RCWR to take place. There was a transfer of western WRA technology and experience to China from Garran Hassan. Particularly useful knowledge gained by the RCWR was how to better integrate and adjust the model parameters with feedback from field experience of wind farms. The transfer of knowledge was made possible through academic conferences and lectures offered by a number of experts from Garrad Hassan (Interview GD/03/2007).

Another important contribution of this society-university collaboration was less tangible, but equally important. The recognition by Garrad Hassan of the work of the RCWR has strengthened the confidence of this newly established research centre in its research directions (Interviews GD/01/2007, GD/03/2007). In this sense, the recognition that RCWR as a young research institute received from an internationally recognised institute has strengthened the capacity of the RCWR to continue to work in this field. Although the RCWR did not have a clear intention to become an independent institution in the near term, the experience and knowledge gained through this collaboration was nevertheless a valuable step in its development process.

While Greenpeace China played a strategic role in promoting this collaborative initiative, it is interesting to note that it was made possible in part because of the open-mindedness of the young researchers at the Sun Yat-sen University. They appeared to be more willing to take the opportunity to collaborate with Greenpeace China, a local branch of Greenpeace - an international green group that is well known for its activist approach (Interviews GD/02/2006, GD/03/2007).

Another major initiative in Guangdong was an enterprise-university collaboration between Shanwei Honghaiwan Wind Farm and the RCWR. This started in 2005 as an informal collaboration based on personal networks. The wind farm developer wanted to have a thorough examination of the reasons why the actual energy yield from the wind farm was substantially lower – about 30 to 40 percent - than the projected figure. Building on the personal ties between the team leader of the RCWR and the senior management of the wind farm, the collaboration was formed to undertake a validation study of the WRA in this specific wind-farm site. An exchange of wind resource data took place between the collaborating partners.

The findings of the validation studies were found to be mutually useful to both parties: the wind farm developer found that the work conducted by the RCWR which integrated different wind data-sets and different techniques offered a more accurate and comprehensive analysis of the site’s wind resources; the RCWR also gained from this collaboration as the in-situ wind energy measurements owned by the wind farm developer allowed it to gain field experience and help it to fine-tune its computing parameters.

No monetary payment was involved in this collaboration. Mutual trust and resource exchange were the major preconditions and incentives for this collaboration even in a situation that the wind data was not in the public domain (Interview GD/04/2008).

However, a major limitation of the wind resource collaboration in Guangdong has been the lack of active engagement on the part of the Guangdong Meteorological Bureau. While the work of the Bureau and those of the RCWR were highly complementary, the experience of the RCWR suggested that there was inertia in the local meteorological bureau which discouraged it from collaborating on interdisciplinary studies. The RCWR even had difficulties in accessing the government meteorological data for its own studies as data sharing in the public domain is not effectively institutionalised (Interviews GD/01/2007; GD/02/2006).

5. Collaborative governance as a strategy for improving WRA: local diversity, prospects, limitations and key challenges

While the existing state-led WRA model in China has demonstrated its strengths, it has also revealed certain weaknesses. An examination of the recent development of WRA in Xinjiang and Guangdong suggests that some of the characteristics of WRA, including its complexity, enormity and uncertainty, make an alternative approach, collaborative governance, particularly appropriate for this task.

The case studies of Xinjiang and Guangdong suggests that locally-based collaborative initiatives are being undertaken to facilitate the task of WRA. It is interesting to note that a variety of collaborative models have emerged at the local level: while Xinjiang's experience is characterized as an enterprise-led model, Guangdong's experience is a society-university-enterprise collaboration that carries strong bottom-up characteristics. Although the two provinces differ in terms of the model of collaboration, a common pattern that has emerged is the move away from the central government towards the localities and to a wider range of actors that have created new horizontal and bottom-up relations that influence how WRAs are undertaken.

These more complex relationships in the collaborative initiatives between enterprises, civil society and the state seem to offer the potential to enhance capacity at the local level to meet the challenges of WRA by combining different resources and skills that are located both within and outside the state.

What, then, are the specific achievements of these collaborative initiatives? The case studies show that these initiatives were able to enhance local capacity in various ways. They were able to enhance efficiency through cost-sharing and resource-pooling across a wide range of sectors (and even across a number of actors in a particular sector). The collaboration also appeared to empower the local government in Xinjiang to make more evidence-based decision-making in setting wind energy targets. The collaboration also appeared to be able to enhance the capacity of the universities in China to provide professional, independent WRA services.

However such locally-based initiatives are not without their limitations. First, this paper is not arguing that the bottom-up collaborative initiatives can completely replace the central government in the context of WRA. The central government appears to perform indispensable roles particularly in high-level coordination and creating a new public platform for data-sharing. Instead, the focus of attention appears to be how the central government and the localities can coordinate to better capture the potential additional capacity that could be created by locally-based collaboration. The existing policies for wind energy tend to overlook the roles of localities in enhancing the governing capacity in the sustainability transition.

Second, these collaborative initiatives tend to be ad-hoc and small in scale, limited in continuity, and lack long-term institutionalized incentives. Another key observation is the inactive role played by the local meteorology bureaus in the two case studies which suggests that there are inadequate institutional incentives for the local bureaus to explore new partnership roles in such initiatives. Problems of rent seeking, the issue of disciplinary inertia, and the limits of budgetary and personnel resources appear to be the inhibiting factors that limited the involvement of local meteorological bureaus. All these observations suggest that in order to better realize the potential benefits of collaboration, there is need to introduce new institutional arrangements to provide the right structures and incentives for the actors to collaborate.

Third, local initiatives appear to be heavily influenced by the local context. The existence of social ties, trust, local wind advocates, and NGOs (Greenpeace China in the case study of Guangdong) may not be widely available across China. The local diversity of the facilitating conditions for collaboration, and the different collaborative arrangements as shown in the two cases suggest that there may be many possible pathways to achieve the advantages of collaboration in the other Chinese provinces. This suggests that collaborative governance in China must take into account local opportunities and local constraints for this bottom-up governance strategy to realize its potential.

This paper has filled some of the knowledge gaps regarding collaborative governance in the context of sustainable energy in China. Further research could consider comparing different policy domains in the context of sustainable energy, particularly in areas such as R&D policy.

This paper has shed light on how a collaborative governance approach has facilitated WRA at the provincial level in China. Specifically, this paper has assessed some of the potential benefits, and explained the mechanisms as highlighted by recent developments in WRA in Xinjiang and Guangdong. This paper suggests that greater attention should be given to the potential capacity in the localities, and the need to introduce institutional arrangements to create more conducive conditions for collaboration to take place beyond the core of central government.

List of Interviews

As some interviewees agreed to be interviewed anonymously, this study indicates interviews by number. The first two letters indicate the location (BJ for Beijing, GD for Guangdong, and XJ for Xinjiang), the two digits indicate the interview numbers, and that followed by the year of interviews. The interview formats included face-to-face interview (FI) and telephone interview (TI).

Code	**Interviewees Background**	**Types of interview**	**Date of interview**
BJ/01/ 2005	Yang Fuqiang, Vice President, The Energy Foundation, Chief Representative, Beijing Office	FI	Mar 24, 2005
BJ/02/2006	A senior official of China Meteorological Administration	FI	Oct 30, 2006
XJ/01/2008	Zhang Yanjun, Division Head, Electricity Division, The Economic and Trade Commission of Xinjiang Uyghur Autonomous Region	FI	Oct 21, 2008
XJ/02/2008	A mid-ranking officer, Xinjiang Uyghur Autonomous Region Development and Reform Commission	FI	Oct 22, 2008
XJ/03/2007	A senior official of the Climate Centre of Xinjiang Uyghur Autonomous Region	FI	Oct 23, 2007
XJ/04/2008	Same interviewee as in XJ/03/2007	FI	Oct 23, 2008
XJ/05/2008	Yu Wuming, former general manager of Xinjiang Wind Energy Company; the deputy director of NWTC; and a expert to XJ government	FI	Oct 25, 2008
GD/01/2007	A senior researcher of the Research Centre of Wind Resource (RCWR) under the School of Engineering at Sun Yat-sen University	FI	Aug 22, 2007
GD/02/2006	Same interviewee as in GD/01/2007	FI	Jan 7, 2006
GD/03/2007	A researcher of the Research Centre of Wind Resource (RCWR) under the School of Engineering at Sun Yat-sen University	FI	Aug 22, 2007
GD/04/2008	Same interviewee as in GD/03/2007	TI	Dec 12, 2008
GD/05/2008	A senior manager of a wind farm in Guangdong	TI	Jan 4, 2008

Acknowledgements

The authors would like to acknowledge the interviewees, particularly Yu Wuming of Xinjiang Wind Energy Company and several other anonymous interviewees in Xinjiang and Guangdong, for providing useful information. Any error in the findings, interpretations, and conclusions expressed in this paper are entirely those of the authors.

References

Ansell, C. & Gash, A. (2008). Collaborative governance in theory and practice. *Journal of Public Administration Research and Theory, 18*(4), 543-571.

Badger, M. (2009). *Satellite SAR Wind Resource Mapping in China*. Roskilde: Risø National Laboratory for Sustainable Energy Technical University of Denmark.

BMU. (2007). *EEG – The Renewable Energy Sources Act: the Success Story of Sustainable Policies for Germany*. Berlin: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

Boyle, R. (1989). Partnership in practice—an assessment of public-private collaboration in urban regeneration - a case study of Glasgow action. *Local Government Studies, 15*(2), 17-28.

CCChina. (2006, June 21). Wind and solar energy resources assessment center established in Beijing. Retrieved September 22, 2008, from http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=4251

CHECC. (2008). Accomplishment of Wind Power in China 2007: Statistics Report (*2007 niandu Zhongguo fengdian jianshe chengguo: tongji baogao*). Beijing: China Hydropower Engineering Consulting Group Co. (CHECC) .

Cheung, P. (2002). Guangdong under reform: social and political trends and challenges. In J. Fitzgerald (Ed.), *Rethinking China's Provinces* (pp. 125-152). London; New York: Routledge.

Christiansen, M., et al. (2006). Wind resource assessment from C-band SAR. *Remote Sensing of Environment, 105*(1), 68-81.

CMA. (2009a). Building up national networks on observation of wind, solar and other renewable energy for green development. Retrieved September 9, 2009, from http://www.cma.gov.cn/en/speeial/2009special/wcc_3/respond/200908/t20090819_42177.html

CMA. (2009b). China Meteorological Administration. Retrieved September 9, 2009, from http://www.cma.gov.cn/en/aboutcma/200807/t20080731_13359.htm

Cordery, J. (2004). Another case of the Emperor's new clothes? *Journal of Occupational and Organizational Psychology, 77*, 481-484.

CRESP. (2006). *Capacity Building and Studies on Wind Resource Assessment*. Beijing: China Renewable Energy Scale-up Program, World Bank.

CRESP. (2008a). *China Renewable Energy Development Overview 2008*. Beijing: China Renewable Energy Scale-up Program.

CRESP. (2008b, August 26). Wind resources assessment for large wind farm siting in

Inner Mongolia. Retrieved September 9, 2009, from http://www.cresp.org.cn/english/encontent.asp?id=976

de Bruijn, T. & Hofman, P. (2002). Partners in pollution prevention: increasing environmental capabilities of SMEs through collaboration. In T. de Bruijn & A. Tukker (Eds.), *Partnership and Leadership: Building Alliances for a Sustainable Future* (pp. 195-215). Dordrecht: Boston: Kluwer Academic Publishers.

DOE. (2008). *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply*. Washington, D.C.: U.S. Department of Energy.

Economy, E. (2007). The Great Leap Backward? . *Foreign Affairs*, September/October, from http://www.foreignaffairs.org/20070901faessay86503-p50/elizabeth-c-economy/the-great-leap-backward.html

EF. (2009, January 15). China blasts through wind energy target. *Environmental Finance*.

Energy Office. (2008, January 19). *Brief introduction on the development of clean and renewable energy in Guangdong in 2007 (Guangdongsheng qingjie nengyuan、kezaisheng nengyuan fazhan jiankuang)*. Retrieved December 27, 2008, from http://www.gddpc.gov.cn/zwgk/nygz/nyxm/200806/t20080604_19793.htm

Greenpeace. (2005b). *Wind Guangdong*. Guangzhou: Greenpeace.

GWEC. (2009a). China. Retrieved April 27, 2009, from http://www.gwec.net/index.php?id=125

GWEC. (2009b). Energy supply security. Retrieved May 6, 2009, from http://www.gwec.net/index.php?id=138

Haas, P. (2001). Introduction: epistemic communities and international policy coordination. *International Organization, 46*(1), 1-35.

Halpern, N. (1992). Information flows and policy coordination in the Chinese bureaucracy. In K. Lieberthal & D. Lampton (Eds.), *Bureaucracy, Politics, and Decision Making in Post-Mao China* (pp. 125-150). Berkeley; Los Angeles; Oxford: University of California Press.

Hartman, C., et al. (2002). Environmental collaboration: potential and limits. In T. de Bruijn & A. Tukker (Eds.), *Partnership and Leadership: Building Alliances for a Sustainable Future* (pp. 21-40). Dordrecht: Boston: Kluwer Academic Publishers.

Hau, E. (2006). *Wind Turbines: Fundamentals, Technologies, Application, Economics* (2nd ed.). Berlin; New York: Springer.

Huxham, C. (2000). The challenge of collaborative governance. *Public Management, 2*(3), 337-357.

Huxham, C. & Vangen, S. (2005). *Managing to Collaborate: The Theory and Practice of Collaborative Advantage*. London; New York: Routledge.

IEA. (2007). *World Energy Outlook 2007: China and India Insights*. Paris: OECD/ IEA.

Jefferson, M. (2008). Accelerating the transition to sustainable energy systems. *Energy Policy, 36*(11), 4116-4125.

Koontz, T., *et al*. (2004). *Collaborative Environmental Management: What Roles for Government?* Washington, D.C.: Resources for the Future.

Lin, W.& Wang, Y. (2009, June 26). The wind resource monitoring network in Xinjiang has been built (*Xinjiang wancheng fengneng ziyuan guancewan jianshe*). *Zhongguo Qixiang Baoshe*. Retrieved September 18, 2009, from http://www.cma.gov.cn/qxxw/xw/200906/t20090626_37452.html

Mani, A. & Rangarajan, S. (1996). *Wind Energy Resource Survey in India - IV*. New Delhi; Mumbai; Calcutta; Madras; Nagpur; Ahmedabad; Bangalore; Hyderabad; Lucknow: Allied Publishers.

Martinot, E. & Li, J. (2007). *Powering China's Development: the Role of Renewable Energy*. Washington, D.C.: Worldwatch Institute.

Martinot, E. & Wallace, W. (2003). *Case Study: UNDP/ GEF Project for Commercialisation of Renewable Energy in China*: Global Environment Facility.

MIT. (2007). *The Future of Coal: An Interdisciplinary MIT Study*. Cambridge, MA: Massachusetts Institute of Technology.

NDRC. (Undated a). *The Tenth Five-year Plan of the National Development of Meteorology (Quanguo qixiang shiye fazhan dishige wunian jihua)*. Beijing: National Development and Reform Commission.

NDRC. (Undated b). *Development Plan for the Metrological Industry (2001-2015) (Qixiang shiye fazhan guihua (2001-2015))*. Beijing: National Development and Reform Commission. Retrieved September 19, 2008, from http://www.ndrc.gov.cn/fzgh/ghwb/hygh/W020050614802549054752.pdf.

NERL. (1997). *Wind Resource Assessment Handbook: Fundamentals for Conducting a Successful Monitoring Program*. Golden, CO: National Renewable Energy Laboratory.

NREL. (2004a). *Renewable Energy in China: Brightness Rural Electrification Program*. Colorado: National Renewable Energy Laboratory.

NREL. (2004b). *Renewable Energy in China: Township Electrification Program*. Colorado: National Renewable Energy Laboratory.

Pozon, I. & Mench, P. (2007). *Coming Clean: The Truth and Future of Coal in Asia Pacific*. Gland, Switzerland: WWF International.

QXB. (2009, May 14). China Meteorology Administration and the National Energy Bureau in discussion of the utilization of wind energy and solar resources (Zhongguo qixingju guojia nengyuanju gongshang fengneng taiyangneng ziyuan kaifa liyong). Retrieved September 18, 2009, from http://www.cma.gov.cn/qxxw/xw/200905/t20090514_33815.html

Reeves, A. (2003). *Wind Energy for Electric Power: a REPP Issue Brief*. Washington, D.C.: Renewable Energy Policy Project.

Rickson, R., et al. (1990). Institutional constraints to adoption of social impact assessment as a decision-making and planning tool. *Environmental Impact Assessment Review, 10*(1/2), 233--243.

Roussos, S. & Fawcett, S. (2000). A review of collaborative partnerships as a strategy for improving community health. *Annual Review of Public Health, 21*, 369-402.

Shirk, S. (1993). *The Political Logic of Economic Reform in China*. Berkeley; Los Angeles; Oxford: University of California Press.

Singh, S., et al. (2006). A review of wind-resource-assessment technology. *Journal of Energy Engineering, 132*(1), 8-14.

Thomson, A. & Perry, J. (2006). Collaboration processes: inside the black box. *Public Administration Review, 66*(Dec), 20-32.

Voß, J.-P. & Kemp, R. (2007). *Reflexive Governance: Learning to Cope with Fundamental Limitations in Steering Sustainable Development*. Rotterdam, the Netherlands: Knowledge Network for System Innovations and Transitions.

Wallace, W., et al. (2006, October 23-27). *Support for wind resource assessment and wind farm development in China*. Paper presented at the Great Wall World Renewable Energy Forum, Beijing, China.

Wang, S & Hu Y. (2009, July 8). A teleconference on the national wind energy monitoring network is held. The establishment of the wind resource monitoring network has been basically completed (*Quanguo fengneng guancewang jiance ji houxu gongzuo anpai dianshi huiyi zhaokai. Fengneng ziyuan guancewang jiben jiancheng*). *Beijing: Zhongguo Qixiang Baoshe*. Retrieved September 18, 2009, from http://www.cma.gov.cn/qxxw/xw/200907/t20090708_38426.html

Wang, Z., *et al*. (2006). China's achievements in expanding electricity access for the poor. *Energy for Sustainable Development, 10*(3), 5-16.

Widdus, R. (2001). Public-private partnerships for health: their main targets, their diversity, and their future directions. *Bulletin of the World Health Organization, 79*(8), 713-720.

Wright, T. (2000). The political economy of prices in China's planned and market economies: competition and control in the coal industry. *Asian Studies Review, 24*(3), 349-376.

WWEA. (2009). *World Wind Energy Report 2008*. Bonn: Germany.

Yan, X. (2001). The impact of the regulatory framework on fixed-mobile interconnection settlements: the case of China and Hong Kong. *Telecommunications Policy, 25*(7), 515-532.

Yin, R. (2003). *Case Study Research: Design and Methods* (Third ed.). Thousand Oaks; London; New Delhi: Sage Publications.

Yoder, D. (1999). A contingency framework for environmental decision-making: linking decisions, problems, and processes. *Policy Studies Review, 16*(3/4), 11-35.