4. Explaining the development of China's renewable energy policies: comparing wind and solar power

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INTRODUCTION

Over the last decade, China's role in global climate change governance has evolved significantly. On the one hand, China has emerged as the most important global actor in terms of energy use and greenhouse gas (GHG) emissions. In 2006, the country surpassed the United States (US) as the largest carbon dioxide (CO₂) emitter in the world and in 2010, China's average per capita emissions approached those of the European Union (EIA 2012). Due to a growing population, rising living standards and the typical Chinese growth model, based on heavy industry and the extensive use of coal, carbon-intensive energy demand has been escalating, especially since 2002. Despite China's efforts to stimulate the development of a variety of energy sources such as nuclear, hydro, solar photovoltaic (PV) and wind power, China's economic growth model and energy mix remain

Source: Adapted from National Bureau of Statistics of China (2012).

Figure 4.1 Total primary energy consumption in China by fuel type, 2011

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Source: Adapted from EIA (2012).

Figure 4.2 Total carbon dioxide emissions from the consumption of energy in China (million tonnes), 1985–2010

highly dependent on the use of coal and oil (Figure 4.1). Of all fossil fuels, coal releases the largest amount of CO₂ into the atmosphere per unit of heat energy (IEA 1993). The large increase in energy demand and China's stagnating energy mix are, therefore, the main reasons why the recent rise in carbon emissions is expected to continue (see Figure 4.2; Buijs 2009). The US Energy Information Administration estimates that China emitted more than 8000 million tonnes of CO₂ as of 2010 (EIA 2012).

On the other hand, China is portrayed as a 'green giant', investing heavily in renewable energy and energy efficiency. Until the 11th Five-Year Plan (FYP) (2006–2010), climate-related energy targets were non-existent and there was little talk about controlling CO₂ emissions (Yuan and Zuo 2011). By contrast, from the 11th FYP onwards, the Chinese government has developed an ambitious set of policies related to energy security, climate change and the development of the wind and PV sectors. At present, China is one of the world's largest investors in renewable energy and has pledged to spend \$473.1 billion on clean energy investments over the period of the next Five-Year Plan. The results have exceeded expectations: China was one of the world's largest wind markets in 2011 with a total of 62 364 gigawatts (GW) installed wind capacity, compared to 93 606 GW in Europe, and increased its installed PV capacity from 900 megawatts (MW) in 2010 to 3.1 GW in 2011 (GWEC 2012a).

These developments demonstrate that the Chinese government's priority of economic growth shifted from a growth discourse purely focused on quantity, in terms of gross domestic product (GDP), to a discourse that prioritizes a low-carbon and more energy-efficient development path. Similar conclusions can be drawn from the latest economic planning

document, the 12th FYP. The 12th FYP strives for sustainable and inclusive economic growth, taking into account economic, environmental and social aspects. It does so by providing quantitative targets in the energy sector to secure and expand domestic sustainable energy supplies: a 16 per cent energy intensity reduction by 2015, 17 per cent reduction of CO₂ emissions per unit of GDP by 2015, and increasing the share of non-fossil fuels in primary energy consumption to 11.4 per cent by 2015 and 15 per cent by 2020. Based on calculations by the China Renewable Energy Industry Association (CREIA), China will have installed 300 GW hydropower, 150 GW wind power, 30 GW biomass power and 20 GW PV power capacity by 2020, accounting for a total of 500 GW non-fossil fuel power capacity by 2020. That amount of energy capacity would account for almost one-third of China's expected total power capacity of 1600 GW by 2020 (CREIA 2010).

This chapter attempts to explain the recent shift in China's renewable energy policies, with a focus on wind and PV power in particular. The explanation is given in two sections. In the first section, we will assess the multiple drivers for the shift in China's approach to (renewable) energy development and domestic climate mitigation. After clarifying why a policy shift occurred, the second section will explain how the wind and PV sectors are and have been developing by analysing the regulatory framework, policy instruments and interactions between Europe and China on wind and PV development. There are three main reasons for choosing a comparison between PV and wind. Firstly, PV and wind have received strong policy support in China's most recent energy security and climate-related policy documents, indicating their importance to the government. Secondly, PV and wind are among China's most important and rapidly changing (renewable) energy sectors. Thirdly, interactions in the renewable energy sectors between Europe and China are a vital element in current climate governance dynamics.

The first section presents an analysis of the reasons why China's renewable energy and climate policies changed in recent years. There exists a small body of academic literature about the motivations behind China's current climate policy discourse, focusing on specific aspects such as the costs and benefits of mitigation (Hepburn and Ward 2010; Schroeder 2008; Wiener 2008) or the pressure on China from the international community (Heggelund 2007; Zhang 2003). The current analysis differs from these approaches and follows Olivia Boyd's approach, which is to transversely identify the intrinsic drivers for the policy shift (Boyd 2012). The section is based on a large number of in-depth interviews with Chinese and EU policymakers, renewable energy industry representatives and PV and wind power experts (interviews 2009, 2011, 2012). It provides an insight

into how policymakers and business actors understand the various motivations underlying China's renewable energy policy shift.

In the second section, we explain how the wind and PV sectors have been developing. The analysis focuses on the policies, policy instruments and interactions between Europe and China in both sectors. As both sectors are yet to be commercially viable without state support, we first present a thorough overview of China's regulatory frameworks, policies and regulations aimed at domestic renewable energy development. We then look at the role of Europe in the dynamics of China's wind and PV market. In spite of the important impact on bilateral trade relations and international climate change negotiations, there is surprisingly little academic research on the interplay between Europe and China regarding renewable energy development at current. This chapter tries to fill that gap by offering an initial analysis and mapping of the multiple interactions in the PV and wind sectors. Interactions include the behaviour of multiple actors – European Union (EU) institutions, EU member state governments, market actors, companies and research institutions – who may all influence the strategic setting and bargaining positions at international climate negotiations and within the bilateral relationship on climate change, trade and renewable energy.

INTRINSIC DRIVERS FOR POLICY CHANGE

Recent Chinese policies that prioritize a low-carbon and resource-efficient development path in which developing renewable energy is key, have three main driving forces: energy security concerns, market opportunities and climate change concerns. China's quest for alternative forms of energy and domestic climate and energy policy initiatives is fundamentally rooted in its fear of domestic energy shortages and climate-change-induced environmental degradation in the near future, in addition to the recently emerging global market in renewable energy technology (Martinot and Li 2007; Tsang and Kolk 2010).

Energy Security

Energy security is considered a major driving force in China's policy shift towards increasing energy efficiency and renewable energy. This can be analysed from two points of view: supply-side and demand-side energy security.

On the one hand, energy security can be seen as 'assuring adequate, reliable supplies of energy at reasonable prices and in ways that do not

jeopardize major national values and objectives' (Yergin 1988: 112). This supply-based definition is appropriate for China's case where energy policy is considered to serve major national values and objectives (Leung 2011). This view became popular in Chinese policymaking circles when China faced a series of oil shortages, first in the 1960s and later in 1993, forcing it to import a significant amount of oil and making Chinese leaders anxious about securing energy supply and adhering to their 'unwritten social contract with the people whereby the people do not compete with the Party for political power as long as the Party looks after their economic fortunes' (Breslin 2005: 749). Related factors include fluctuating global oil prices and the possibility of foreign resource wars, for example in the South China Sea, which could affect everyday economic activity, political stability and quality of life in China, threatening the Party's rule (Leung 2011).

In 1994, in response to these increasing fears, the concept of energy security (*nengyuan anquan*) was put at the top of the central government's political agenda. When oil imports doubled and prices tripled in 2000, energy security even became a buzzword (Leung 2011). China is now the world's second-largest oil consumer and became a net importer as of 2009. In 2010, China consumed about 11 per cent of the world's oil, while the US accounted for 21 per cent (BNEF 2012a; EIA 2012). Due to comparatively low domestic oil supplies, China relies on coal (nearly 70 per cent) as its major source of energy (National Bureau of Statistics of China 2012, see Figure 4.2).

In 2009, 79 per cent of China's electricity generation was based on coal (IEA 2012). China's annual coal consumption is double that of the US. China is able to supply almost all of its coal needs, but became a net importer of coal in 2009. In many cases, it is cheaper for coastal consumers to purchase high-quality coal through imports instead of coal from Chinese fields because China's coal reserves are found in the northern provinces and have to be transported long distances to the regions where they are needed (Leung 2011).

Despite the efforts of the Chinese government, the International Energy Association (IEA) predicts that China's dependence on foreign energy will increase to over 60 to 70 per cent of its total consumption by 2015. In 2009, coal imports reached a record high of 9.43 million tonnes and oil imports accounted for over 50 per cent of oil consumption in China (Zhang 2009). Besides maintaining development without harming the environment, the use of wind and PV energy can increase China's energy independence by reducing its reliance on foreign imports, with the additional advantage of not requiring large-scale settlements, as is the case for hydropower and natural gas (Pan and Zhu 2006).

On the other hand, energy security can be viewed from the perspective of energy demand. Despite improvements in energy efficiency, the current economic structure has led to a sharp increase in total energy consumption (Zha 2008). Since the start of economic reforms in 1979, China has been experiencing rapidly changing patterns of production and consumption, with subsequent impacts on the local and global environment (Bruyninckx 2008; Economy 2004; Mol and Carter 2006). Due to China's rapid economic development, expanding middle-class population, extraction of minerals and ores, penetration of consumer goods and urbanization, levels of energy consumption have been increasing. According to the EIA (2011b), total primary energy demand in China will grow at a rate of 2.1 per cent per year, on average, between 2008 and 2035, an overall increase of 75 per cent, and electricity demand will almost triple by 2035, with an average annual growth rate of 5.3 per cent. In an effort to cope with rising energy demand, China's national policymakers give priority to developing energy sources and improving energy efficiency. The 11th FYP (2006–2010) deviated from previous FYPs by prioritizing the expansion and securing of domestic energy supplies, promoting energy efficiency and conservation, gradually transforming the energy sector from a centrally planned sector to a market-oriented economic sector and promoting bilateral and multilateral cooperation in the field of energy (Zhang 2011). The increasing focus on energy efficiency has been strongly influenced by the perceived danger in China that high levels of domestic energy consumption pose a threat to China's energy security (Boyd 2012). The Chinese government acknowledges that the current economic growth model based on large infrastructure projects with low productivity and export-oriented heavy industry and manufacturing – both featuring inefficient use of energy and artificially low energy prices – is not tenable in the long term. Unsurprisingly, the 12th FYP, China's latest national economic planning document, reveals that drawing on all available energy supplies in order to enhance China's process of industrialization at all costs is no longer deemed acceptable. The 12th FYP shows that a combination of energy efficiency and renewable energy development is now seen as a key factor in securing energy supplies in a politically, economically and socially sustainable manner.

Market Opportunities

Chinese leaders would like China to become the world's technological and economic leader with regard to low-carbon technologies and renewable energy (Freeman 2010; Hu 2011; State Council 2010). China not only aspires to address the externalities of its growth model, it

Source: Adapted from IEA (2010: 286).

Figure 4.3 Annual investment in renewable energy assets by region (\$ billions)

also wants to lead and capitalize on its successful development of the renewable energy sector. The renewable energy industry is one of the strategic industries aiming for global expansion and internationalization in keeping with China's 'Going Abroad Strategy' (Wiley Rein LLP 2012). The 12th FYP confirms that the renewable energy sector is an important building block for China's economic development, reflecting the government's sound interest in competing and becoming a leader in global low-carbon energy markets. This interest has been translated into significant investment in China's renewable energy sector. The motivations for this investment have not only been to mitigate climate change as part of nationally agreed targets or to increase energy security, but also to promote renewable energy industries from an economic point of view (see Figure 4.3). It competes, in that regard, with the rapidly developing renewable energy industries in the US and the EU. With regard to the EU, Germany, Denmark and the United Kingdom (UK) are particularly important players, with whom China has a double-sided relationship. On the one hand, there is fierce competition between the different providers, while on the other hand there are many opportunities for collaboration and market access.

Climate Change

Climate change only became a genuine top priority on the central government's political agenda as of recently. In the 1980s and 1990s, the economic reform process lifted hundreds of millions of Chinese out of

poverty and, ultimately, transformed the country into a global economic powerhouse. However adhering to the maxim 'first development, then environment' has brought with it an excessive and continuously increasing environmental cost (Economy 2004). It is estimated that the annual cost of environmental damage to China's economy is equivalent to between 5.8 and 10 per cent of GDP (China Daily 2006; World Bank and SEPA 2007). It is the potential costs of severe climate change impacts and the restrictions they put on China's future economic development, prosperity and stability that make climate change concerns a strong motivator for policy action (IPCC 2007: 20–22; Piao et al. 2010).

The consensus among China's leading natural and social scientists that climate change seriously threatens China's future economic growth (for example Paio et al. 2010; Qi 2011; Zhang 2003), is shared by the Chinese government. This is demonstrated by the number of policy documents that define climate change as a development issue and identify damage from climate change, such as flooding, rising sea levels, soil erosion, desertification, deforestation, biodiversity loss and decreased food crops and livestock yields.

In 2007, for instance, China launched its National Climate Change Programme, published the White Paper on China's Conditions and Policy, the Climate Change White Paper, the National Assessment Report on Climate Change and the 11th FYP (2006–2010). In these policy documents the link between energy, environment, economic development and technology are made explicit (see *infra*). This implies that, although economic growth remains a priority for the Chinese government, in China's official discourse it is acknowledged that the environmental factor should be taken into account in energy strategy development.

The climate change problem fundamentally speaking is a development problem and must be comprehensively solved in the framework of sustainable development. International cooperation on climate change must start from correctly handling the triple relationship between economic growth, social development and protection of the environment and must have guaranteeing economic development as its core and strengthening sustainable development as its goal. It must have saving energy, improving the energy structure and strengthening ecological protection as its focus and have scientific progress as a support, so as to continuously raise the capacity of the international society to mitigate and adapt to climate change. (Hu Jintao, quoted in Freeman 2010: 15)

From the introduction of the 12th FYP onwards, a number of policies specifically aimed at reducing GHG emissions, such as the 17 per cent carbon intensity reduction target, have been launched

by national policymakers, indicating that climate change mitigation became a motivation for policy action in its own right (Boyd 2012). At the end of 2011, additional carbon policies were launched, such as the carbon trading pilot programme and measures to meet the carbon intensity reduction target (NDRC 2011). These measures include provincial energy and carbon reduction targets, which make carbon reduction a key performance indicator (KPI) for evaluating local officials. In 2012, several industries were obliged to publish GHG reduction targets and energy saving targets for each industry were subsequently made public in the 12th FYP on Industry Energy Efficiency (State Council 2011).

In summary, the combined forces of climate change concerns, market opportunities and energy security have caused a dramatic shift in China's climate and renewable energy policies in recent years. The maintenance of economic growth remains the top priority, but how to achieve this growth has become subject of intense debate – not least because of the substantial political and economic risks involved.

POLICY RESPONSE: THE DEVELOPMENT OF WIND AND PV POWER

In this section, we explain the development of wind and PV in China by highlighting the strategic importance of the renewable energy sector in China's overall economic planning documents, the multiple policy instruments developed for the wind and PV sectors during the last decade, and the interactions between Europe and China.

In the first instance, the focus is on policies because investors, technology solution providers, technology buyers and other market participants in the Chinese renewable energy sector agree that government support is the main factor driving renewable energy sector development. The industrial policies related to strategic emerging industries, followed by targets in renewable energy, GHG emissions and carbon intensity are considered the most important among those actors (CGTI 2012: 51; interviews 2009, 2011, 2012).

Secondly, international cooperation in the area of renewable energy is indispensable given that current environmental and economic developments disregard national boundaries. Furthermore, now that China has become a leader in the area of renewable energy, both the government and companies are seeking to capitalize on the country's successes abroad and deepen international collaboration and cooperation while continuing to secure resources and technologies.

Integration of Renewable Energy in China's National Regulatory Framework

Development of the wind and PV power sectors is supported by a regulatory framework consisting of a number of major legal documents. The main turning point was the adoption of the 2005 Renewable Energy Law (REL) and the 11th FYP (2006–2010). Before 2005, some renewable energy policies were already in place, including the 1995 Electric Power Law, the 1997 Energy Conservation Law, the 2000 Atmospheric Pollution Prevention Law, the 2002 Clean Production Law and a host of administrative regulations and systems (Chang et al. 2012; Zhang et al. 2009a, 2009b). However it was not until the introduction of the REL in 2005 that most of those regulations were consolidated. The REL established a special fund dedicated to the development of the renewable energy sector (Renewable Energy Development Special Fund), in addition to requiring electricity grid companies to 'buy all the grid connected power produced with renewable energy within the coverage of their power grid' (REL, Art. 12, 29).¹ Much of the growth in China's installed renewable electricity capacity (excluding hydropower) is due to the endorsement of the REL, which sent a strong signal and provided long-term certainty to industry (interviews 2009, 2011, 2012).

It is clear that, from 2005 onwards, the renewable energy sector has been regarded as being of strategic importance in China's economic development because of its power to diversify China's energy supply.² Renewable energy policymaking shifted from an ad hoc to a strategic approach, revealing that the Chinese state participates in the renewable energy sector by establishing subsidy programmes with grid interconnection and independent power production in remote areas, by commissioning renewable energy projects, by operating projects and by producing equipment for the industry (through state-owned enterprises or SOEs) (Liu and Kokko 2010). This participation has made both 'pillar industries' grow dramatically, although solar and wind did not start expanding at the same time or at the same pace.

As a result, installed capacity for both wind and PV and the production of solar and wind goods, has increased tremendously during the past five years due to a range of policies mentioned above and policy instruments that were mainly developed to relieve two obstacles inhibiting further PV and wind growth: prices and transmission capacity (see Figure 4.4; REWC 2009).³ Although the installed PV power capacity is still small in comparison with the installed wind power capacity in China, the growth rate is relatively similar.

Sources: Adapted from EPIA (2012), GWEC (2012a).

Figure 4.4 PV and wind power installed capacity development in China (MW)

Policy Instruments for Wind Power Development

In 2011, China's installed wind power capacity reached a total of 62.4 GW, one of the highest volumes worldwide. On-grid wind power capacity under the distribution of State Grid, China's largest utility company, has witnessed an annual growth rate of 87 per cent over the last six years (Xinhua 2012c). A number of key policy instruments, listed in Table 4.1, contributed to that achievement.

Connection to the national grid is one of the main problems that the growing industry encounters. A gap between installation and grid connection has often been reported (GWEC 2012a, see *infra*). By the end of 2011, China had 62.4 GW wind turbines installed but wind farms often have to remain idle to avoid overloading the grid (Xinhua 2011). The 2007 policy Approach of Grid Enterprises Purchasing Renewable Energy Electricity (see Table 4.1) deals with this problem. However one of the main remaining problems is the high investment cost for transmission infrastructure since the production capacity is concentrated in the northern and western parts of China while the bulk of the demand originates from the eastern parts of the country.

Table 4.1 Policy instruments launched for the development of the wind power sector

Programme	Wind farm concession program/tariff reform programme	Approach of grid enterprises purchasing renewable energy electricity	Launch of a feed-in tariff: notice on price policy improvement for onshore wind power
Date	2003	2007	2009
Type	Subsidy programme	Regulation	Market-based instrument that pays a premium tariff rate to suppliers of wind power for 20 years
Applications	Onshore wind farms	Renewable energy enterprises and grid enterprises	Wind industry (nationwide) with a differentiation depending on the region's wind resources
System size	Onshore wind farms with a capacity of at least 50 MW and individual turbine units installed with at least 600 kW	/	/
Subsidy	Short-term negotiated on-grid tariff	Grid enterprises purchase renewable energy at the regionally defined benchmark prices	0.51 RMB/kWh (EUR 5.7 cents) to 0.61 RMB/kWh (EUR 6.8 cents)
Other terms	At least 50% of the turbines should be made domestically (revised to 70% from the second stage of concession projects)	/	There are four different categories for the tariff, depending on the region's wind resources*

Note: * The four administrative areas are: (1) Category I, including Inner Mongolia Autonomous Region and Xinjiang Uygur Autonomous Region (0.51 CNT/kWh); (2) Category II, including Hebei Province, Gansu Province and parts of Inner Mongolia Autonomous Region (0.54 CNY/kWh); (3) Category III, including Jilin Province, Heilongjiang Province, Ningxia Hui Autonomous Region and parts of Gansu Province; (4) Category IV, including other parts of China (Jiang et al. 2012).

Sources: Adapted from Jiang et al. (2012), Li (2010), Liu and Kokko (2010), Wang (2010).

As regards the pricing issue, according to the Regulation on Prices and Cost-sharing in Renewable Energy (RE), wind power prices are to be set by the government using two pricing mechanisms (Liu and Kokko 2010). One is based on a benchmark determined by the unit price for local coal-powered electricity generation. The other is based on a bidding system. Under the Wind Farm Concession Programme (see Table 4.1), a programme launched in 2003 by the National Development and Reform Commission (NDRC), investors and developers of wind power projects are selected through a bidding process. Bids are assessed on the basis of a number of criteria such as electricity price, installed capacity and the wind farm's locally produced content (see *infra*). The programme is aimed at supporting and encouraging the domestic wind turbine industry as well as creating a domestic wind market (Liu and Kokko 2010; Wang 2010).

One of the main obstacles to installation growth in the long term is the fact that the bidding system favours companies that allegedly deliver electricity at extremely low prices, raising suspicions as to whether they cover the full production costs and deliver high-quality service. To address this problem, the NDRC issued the Notice on Price Policy Improvement for Onshore Wind Power, which institutes a fixed-benchmark pricing system, that is, a feed-in tariff (FiT), from 51 to 61 cent per kilowatt hour, for onshore wind power in place of the concession bidding pricing mechanism. This new mechanism creates four categories of FiTs, based on regional wind resources and differences in geographical conditions (Jiang et al. 2012).

Before 2004, China was an unimportant market for wind power generation. From 2005 onwards, annual installed capacity has doubled each year for five years in a row (see Figure 4.4).

Policy Instruments for PV Power Development

The development of PV power in China has followed a somewhat similar track. In addition to labelling the sector as a pillar industry in China's strategic economic planning documents, China established policy instruments such as subsidies and competitive bidding programmes in order to enable solar companies to increase capacity, reduce costs, strengthen companies' management, expand production scale and become credible players in the international market (see Table 4.2; interviews 2009, 2011, 2012).

Propelled by the booming global market and government support, the annual production of solar cells in China rose from just 3 MW in 2001 to 1088 MW in 2007, comprising 27.2 per cent of global production (CREDP 2008). At present, cell manufacturing continues its marked shift to Asia. Further, China (including Taiwan) is the world's largest producer

Table 4.2 Policy instruments launched for the development of the PV power sector

Programme	Building-integrated PV programme	Golden Sun Program	12th FYP	Feed-in tariff (FiT)
Date Type	2009 Subsidy programme, market-based instrument (competitive bidding) and direct financial support	2009 Subsidy programme, market-based instrument (competitive bidding or concession rights auctioning) and direct financial support	February, 2012 Strategic economic document with regulatory mandates and direct financial support	August, 2012 Market-based instrument that sets a premium tariff for suppliers of PV power under long-term contracts
Applications	Grid-connected rooftop and building-integrated photovoltaic (BIPV) systems (nationwide)	Grid-connected rooftop, BIPV, and ground-mounted systems; off-grid systems in rural areas; nationwide based on a standard of 20 megawatts per province $\geq 300\text{KW}$	Solar industry, as one of the seven leading 'pillar industries' or 'strategic emerging industries' (nationwide)	Solar industry, as one of the seven leading 'pillar industries' or strategic emerging industries (nationwide)
System size Subsidy	$\geq 50\text{KW}$ RMB 20/watt for BIPV RMB 15/watt for rooftop	50% investment subsidy of total cost for on-grid systems 70% investment subsidy of total cost for off-grid systems in remote regions	5 trillion yuan investment in RE projects over the duration of the FYP	/ \$0.15 (1 yuan) per Kwh
Other terms	Conversion efficiency minimum requirement: 16% for monocrystalline, 14% for multicrystalline, and 6% for thin film	For grid-connected systems, on-site consumption is encouraged; excess electricity is sold to the utility; buy-back rate is based on local benchmark coal-fired grid price	Special support for 'national champions'	The NDRC has the right to adjust the FiT based on factors such as investment cost changes, technology development, etc

Source: Adapted from PV Tech (2012).

of solar cells and responsible for over 60 per cent of global production (REN21 2011). In just four years, the global solar manufacturing sector shifted from being geographically dispersed to one dominated by Chinese companies. In 2011, five Chinese companies were among the top ten module manufacturers of which three were in the top five (Lux Research 2012).

Installed capacity is still small compared to cell production figures, but is now rising rapidly (see Figure 4.4). As of late 2010, installed solar power capacity connected to the national grid (that is, excluding autonomous systems) was about 900 MW, which is about 0.1 per cent of China's total power capacity (EIA 2011a). Between 2010 and 2011, capacity grew by a factor of three and business representatives expect the domestic market for solar panels to triple again in 2012 (China Daily 2012a). The 2011 nationwide feed-in tariff for PV of RMB 1 per kWh as well as the installation targets have provided long-term stability and incentives for the private sector, resulting in an explosion in the number of installations at the end of 2011 (Recharge News 2011). Although the Ministry of Finance has announced a 21 per cent cut in the subsidies offered to demonstration solar projects, following a steep drop in equipment costs, the industry is confident that the global outlook for PV in 2012 is positive (MOF 2012). This confidence is not ill-founded as the Party has announced an increase in its domestic installation target from 15 GW to 21 GW by 2015 (China Daily 2012b).

Wind and PV have become national pillar industries in China, leading to booming businesses in a relatively short period of time, mainly due to heavy state support. However, at present, wind and solar's share in China's energy mix is still marginal in comparison with the share of coal or oil, for example (see Figure 4.1; National Bureau of Statistics of China 2012). In the paragraphs below we present an initial list of major problems that need to be resolved in order to increase the share of wind and PV in China's energy mix.

Firstly, wind and PV development require continued political support. Wind and PV cannot rely solely on market forces to be competitive, especially so long as prices for fossil fuels do not reflect the negative externalities on the environment and climate change. Apart from the rapid growth of the PV and wind sectors, the future increase of their share in China's energy mix and thus, their long-term prospects, still depend on how the Chinese government deals with pricing (Liu and Kokko 2010).

Secondly, the grid or transmission capacity constitutes a major obstacle to speeding up market growth. In spite of the growing number of policy instruments addressing the problem (see *supra*), the grid companies have not yet made the investments in infrastructure required to bridge the long

distances between areas of production and consumption. This reluctance can partly be explained by the fact that renewable energy targets were, until recently expressed in terms of installed capacity instead of actual produced power and did not, therefore provide grid companies with the right incentives.

In response to these two problems, the Ministry of Finance (MOF), the NDRC and the National Energy Administration (NEA) have recently implemented significant measures and targets aimed at achieving more efficient renewable energy production. The Interim Measures on Development Funds for Renewable Energy Collection and Management, effective as of 1 January 2012, increased the renewable energy surcharge on all electricity sales from RMB 0.004/kWh to RMB 0.008/kWh. This revenue will compensate grid companies for the higher renewable feed-in tariffs over the next few years (MOF 2011). Furthermore, they set a wind power production target of 190 terawatt hours for 2015 and a 25 GW target for distributed PV for 2020 (EC2 and CNREC 2012; NEA 2011).

The NEA's Notice to Strengthen Digestion of Existing Wind Power Production, released in June 2012, reveals the Party's firm interest in developing the country's transmission capacity. In contrast to multiple wind project approvals in the first half of 2012, the notice states that approval for wind power projects will be slowed down in regions where projects are not yet connected to the grid (GWEC 2012b).

Thirdly, the dominance of SOEs in the Chinese renewable energy sector hampers efficiency and innovation. While it is easier to monitor and regulate large state-owned enterprises (SOEs) which have incentives to follow national policy objectives, since their funding depends on government support, state-led growth can also be very inefficient: SOEs consume a large proportion of capital and raw materials, while they produce relatively small shares of gross output (World Bank and State Council 2012: 26). State enterprises are not only less profitable, but also less dynamic than private enterprises. It is private enterprises that account for the largest share of Chinese employment and prove to be engines of innovation and growth (Brandt and Zhu 2010).

Fourthly, and related to the problem of innovation, is the weak intellectual property protection in China and the absence of a strong culture of high-quality research and development with a long-term outlook, both of which are barriers to domestic innovation (interviews 2009, 2011, 2012). Fifthly, tighter monetary policies in China, and a decrease in government spending on infrastructure, in addition to a weaker demand for PV panels in Europe, make it difficult for wind and solar project developers to obtain financing, especially in the case of private enterprises.

Sixthly, China's long-term macroeconomic prospects are rapidly

changing. This influences development of the renewable energy sector as well as affecting neighbouring countries such as Vietnam: an ageing society, limits to labour force growth and the inefficiency of state-led growth are some of the most relevant issues (CGTI 2012). China's working-age population is heading for a turning point as the availability of cheap labour is rapidly declining (World Bank and State Council 2012). Today, China has the highest labour cost in emerging Asian economies, accounting for 25 per cent of the production cost. The trend is already visible: (Chinese) manufacturing companies are trying to improve productivity and competitiveness by relocating their production business to neighbouring countries or through increasing automation of production processes (Dosch and Vuving 2008).

Seventhly, despite the urgent need for global market rebalancing, the continued economic turmoil in the developed world will have an impact on China's renewable energy sector growth (see *infra*). Debt-related fiscal austerity programmes, demographics, regulatory challenges and uncertainty regarding economic policy in Europe all constitute potential threats to budget spending in the renewable energy sector in the near future.

Apart from the economic turmoil, the final challenge illustrates the importance of EU–China cooperation in the field of renewable energy. There is a substantial level of oversupply in manufacturing, which is obliging companies to look for market opportunities outside China (see *infra*).

Both cooperation and competition between Europe and China on renewable energy is important in order to speed up the pace of PV and wind power development. Besides government support and business development, the next subsection will reveal that governance relations between Europe and China on wind and PV contribute, to a large extent, to both the pace of development and the long-term development prospects of the two sectors.

Interactions between China and Europe

Cooperation between Europe and China is increasingly important for non-traditional security issues such as climate change and energy, as the world is becoming more and more globalized and interdependent in the economic and environmental sphere (Belis and Schunz 2012). Furthermore, Europe–China cooperation in these areas is of significant importance because it serves as an opportunity for both actors to reshape the international order in light of their own priorities (De Matteis 2012).

In addition to the opportunity to capitalize on the country's success in the area of renewable energy,⁴ China is looking to benefit from international cooperation in an attempt to solve issues such as insufficient funds,

lack of technological innovation, lack of industrial structure and lack of regulatory experience (Zhang 2009). International cooperation would provide access to finance and advanced technology and would assist in developing human resources and enhancing the related policy framework (Zhen et al. 2011). Only a small number of technologies are fully commercialized and able to compete – in terms of both price and quality – with Western technology, for example hydropower and biogas (Zhang et al. 2009a, 2009b).

The Clean Development Mechanism (CDM), one of the flexible mechanisms of the Kyoto Protocol which enables industrialized countries to pay for projects that reduce, avoid or sequester GHG emission reductions in less developed countries, has contributed significantly to the development of renewable energies in China by buying Certified Emission Reductions (CERs) that can be applied to meet their own GHG emission targets. Through the CDM, a considerable inflow of money supports the development of renewable energies in China (Chang et al. 2012; Van Eynde et al. forthcoming). Acknowledging the importance of the CDM, this chapter aims to explore interactions beyond China and Europe's involvement in the CDM.

Where do the actions of European and Chinese actors involved in wind and PV development intersect? The presented analysis identifies six 'cross-roads': leading by example; technology transfer; China as the world's factory; the global supply–demand balance; demand for reciprocity in an open market; and the call for rebalancing.

Leading by Example

Europe has influenced PV and wind power development in China in several ways. One such influence is the leading by example aspect. At present, the European PV market is still the largest by far in terms of installed capacity (51 GW in 2011), followed by Japan (5 GW), the US (4.4 GW) and China (3.1 GW) (EPIA 2012). With regard to wind power, European companies such as Vestas and Gamesa are leading the top ten companies globally, although Chinese companies are catching up quickly (BTM Consult 2012; Gruet 2012). During the past decade, solar energy became a significant energy source in Europe's electricity mix, producing 2 per cent of the EU's total demand and roughly 4 per cent of peak demand in 2011 (GWEC 2012a). The European wind industry is confident and expects to achieve the target of supplying 14–16 per cent of Europe's electricity by the end of the decade, up from the 6.3 per cent of EU demand at present (GWEC 2012a).

In respect to these achievements, China has had the opportunity to learn

from Europe's best practices in setting up policies domestically that guarantee long-term strategies and put the right incentives in place. European commercial success has also induced businesses in China to follow in the footsteps of their European counterparts or even overtake them in terms of production and market share.

Technology

The export of technology from Europe and the US to China is significant. In this chapter we define technology transfer as:

the transfer of a technology from one geographical location to another of which the flow may take different forms such as through government (for example ODA) or business (for example FDI) channels and may involve physical assets (for example capital investment and products) and information assets (for example technical know-how and knowledge) (Shiga and Rabhi 2012: 3)

Organizations and/or programmes involved in technology transfer regarding renewable energy from Europe to China are programmes such as the Sino-Danish Wind Energy Development Programme and Renewable Energy Development Programme (RED); the Europe-China Clean Energy Centre in Beijing (EC2); research institutes such as IMEC, Fraunhofer Institute for Solar Energy Systems and Institute for Supply Management; equipment manufacturers such as Centrotherm, Rena, Schmid, Eurotron and European PV module manufacturers such as, for example, Schott and Conergy. The interactions between China and these organizations, programmes and companies include the transfer of both information assets and physical assets (Bloomberg 2012d; interviews 2009, 2011, 2012; VLSIresearch 2012).

Within the context of Sino-Danish cooperation, the Danish government and the Energy Research Institute of the NDRC worked together on transferring technological know-how to improve grid connection and provide on-site training at large-scale wind farms in Northeast China (Liaoning, Jilin and Heilongjiang provinces). The RED programme has two main components: the first relates to the development of Chinese government strategic planning institutions in the renewable energy sector. A Chinese National Renewable Energy Centre (CNREC) was established at the end of 2011 and officially opened in February 2012; the second component focuses on bilateral cooperation in the research and development field of renewable energy technologies through a support scheme launched in February 2012 (Xinhua 2012b).

Another important initiative is the EU-China Clean Energy Centre (EC2), established by the European Commission, the NEA and the

Chinese Ministry of Commerce, with the support of the Italian Ministry for the Environment, Land and Sea. EC2 organizes workshops, training courses and conferences and conducts research projects related to renewable energy development in the EU and China.

The area of technology transfer is also one that causes friction. While Chinese companies are looking for opportunities to obtain technology, European companies are instead looking for a potential market to establish and sell technology. The recent debacle between Sinovel (China) and AMSC (US) and the deal between Sinovel and Denmark's Mita-Teknik for turbine control technology are examples that reflect China's hunger for technology (Recharge News 2012). AMSC sold the high-margin intellectual capital end of the business to Chinese manufacturing companies for years based on the idea that as long as China grows, AMSC would grow. In June 2011, however, AMSC discovered that Sinovel had stolen its technology. Unsurprisingly, the issue of intellectual property protection has been featuring high on the bilateral agenda for US and European companies and policymakers, but a long-lasting solution has yet to be found.

China, Manufacturer of the World?

PV manufacturing has shifted away from Europe to China. At present, the major part of global production capacity for solar cells is installed in China, partially due to the high levels of investment in the Chinese production industry in recent years, as discussed earlier. The literature also highlights China's comparative advantage in labour-intensive manufacturing as another reason for this shift in production capacity towards China. Labour, however, accounts for only a fraction of the cost of making solar panels. Other important factors that underpin China's comparative advantage in PV manufacturing are relatively low enforcement of environmental law, the lower cost of materials and equipment, the lower cost of land, capital and electricity and the fact that China produces more than 90 per cent of the world's rare earth elements (interviews 2009, 2011, 2012).⁵

At present, five companies included in the top 10 of the world's biggest PV module manufactures are Chinese. They are responsible for over 60 per cent of global production, while in 2001 they had less than a 1 per cent share of the global production market. In 2010, about 95 per cent of total module production on Chinese soil was exported, with 60 per cent of these exports shipped to the European market (China Daily 2012c). Due to weaker demand in Europe, Chinese module manufacturers have started exploring other markets, such as the US. In late 2011, US PV module manufacturers filed an anti-dumping complaint against Chinese firms and, in March 2012, the US Department of Commerce announced it would

impose levies ranging from 31 per cent to 250 per cent (Bloomberg 2012d). In September 2012, the EU also launched an anti-dumping probe against China, accusing China of selling its photovoltaic components on the EU market for well below production costs (Xinhua 2012a). However as the solar sector is not homogenous, the trade dispute, imposed tariffs and the expected retaliation measures will also hit market players outside China. For example, the equipment used for PV manufacturing in China is supplied by American and European companies such as Applied Materials and Centrotherm (interviews 2009, 2011, 2012). Regardless of this trade dispute, the rise of Chinese PV module manufacturers is identified as one of the key drivers of the ongoing decline in global PV module prices as a result of improved economies of scale, innovation and technological advancements.⁶

Unlike PV companies, Chinese wind companies such as Goldwind and Sinovel do not dominate the global market yet. Although Chinese wind companies are beginning to rise on the list of top global suppliers, EU companies still account for the largest global market share, while Chinese companies mainly produce for the growing domestic market (BTM Consult 2012; Gruet 2012). The main reasons for this are the fact that the Chinese government is turning its focus on grid connection and improvement of the national electricity system and because the standard technology produced by Chinese manufacturers is wind turbines with a capacity of 1.5 GW or less (Liu and Kokko 2010). Furthermore, the requirement of 70 per cent local content contributed, in a significant way, to the dominance of Chinese companies on the domestic market (see Table 4.1), but did not create incentives for wind companies to adapt to the global wind market.

Global Supply–Demand Balance

Closely related to the decline in prices is the global supply–demand balance within the PV and wind sectors. Due to support policies for PV in Europe such as FiTs, green certificates, net metering and investment compensation through tax credits and the abundantly available Chinese low-cost solar panels, the demand for PV panels for both commercial and residential use has increased substantially in Europe. The large demand for PV panels in Europe was one of the driving forces behind the largely export-driven booming PV sector in China. Chinese export growth has, however, slumped due to weaker demand in Europe. Demand for renewable energy is still highly dependent on policies and subsidies such as FiTs and these face huge budget threats in debt-strapped Europe. Weaker demand in Europe and trade frictions with both the US and the EU (see *supra*) has

led to uncertainty in the market. Solar module manufacturers are adopting different strategies to cope with that uncertainty, such as enhancing vertical integration along the value chain to hedge risks, going outbound by pursuing mergers and acquisitions as a way to obtain market access and by establishing manufacturing bases in target markets and building partnerships with foreign companies to avoid trade friction (CGTI 2012). Examples include LDK Solar (China) purchasing 70 per cent equity in US Roseville-based solar developer Solar Power Inc., Suntech Power (China) entering the US and LDK Solar investing in Greece (SPI 2011; CGTI 2012).

This trend towards vertical integration and market penetration has also been adopted by the Chinese wind sector. Wind companies in China are increasingly opting for export-based expansion (BTM Consult 2012). Examples of this are the projects in Brazil, Ireland, Greece and India developed by Sinovel (China); the projects carried out by Goldwind (China) in Chile, Montana, Pakistan, Ecuador, Ohio, Cyprus, Australia, Ethiopia, Illinois, Minnesota and Cuba; the projects of United Power (China) in Argentina and Texas; and the projects of Ming Yang (China) in Bulgaria, all together accounting for an installed capacity of 2527 MW (Bloomberg 2012c).

Demand for Reciprocity in an Open Market

All eyes are fixed on growth in the renewable energy market in China. For foreign companies, however, entering the PV and wind market in China is not easy due to strict 'house rules' that are often interpreted in Beijing's favour (interviews 2009, 2011, 2012). In 2005, the NDRC declared that wind farms had to buy equipment in which at least 70 per cent of the value was domestically manufactured (known as 'Notice 1204' or the 'local content rule'). Foreign wind companies such as Gamesa (Spain) declined to complain to their own governments even though the Beijing rules flouted international trade law. The reason was that foreign companies sell more in the Chinese market today than in 2005.⁷ Although Notice 1204 was abolished in 2009, as soon as the Obama administration started looking at barriers to American clean energy exports, the policy was no longer needed since it had achieved its goal as stated by experts. Chinese companies became giants, ready to enter other markets for further growth (interviews 2009, 2011, 2012).

Besides the 70 per cent local content rule, foreign companies face other restrictions that all fit into China's strategy. Examples are the tendering system which favours price over quality, preventing foreign companies from competing due to higher prices; the tendering system which stipulates that a foreign company can only co-bid together with a Chinese company;

subsidies not available to foreign companies operating in China; low-interest loans from state-owned banks and grants of cheap or free land for Chinese companies; and the 'buy Chinese' policy that stipulates that government permission is required before buying foreign goods and services (Chang et al. 2012; Garcia 2012).

Although China's growing PV and wind power market is attracting worldwide attention, few insiders expect Western (module manufacturer) companies to truly enter the domestic market. The scene looks rosier for foreign companies operating elsewhere in the value chain, in the areas of, for example, standardization, product innovation, system integration or production equipment, which are all European specialties (Interviews 2012).

Call for Rebalancing

The last 'crossroads' of cooperation is a general call for rebalancing. A first aspect of rebalancing is the future role of China and other non-European countries in the global PV market. Both China and Europe would like to see China play a more significant role on the demand side of the market. The cumulative installed PV capacity outside Europe almost doubled between 2010 and 2011, but non-European countries will have to contribute even more in the future. The current pattern of global demand for installed capacity, in which Italy and Germany alone account for nearly 60 per cent, is unsustainable. With European governments considering further cuts in subsidies, China is forecasted to become the largest PV market very soon. Yingli (China), for example, expects domestic sales to jump to 35 per cent of total revenue, up from 6 per cent of its sales in 2010 (Bloomberg 2012a). Other Chinese PV companies such as Suntech and Trina Solar confirm this trend, increasing their production in expectation of a boom in the Chinese domestic market (Bloomberg 2012b). Growth is also expected in markets outside China, such as Japan, which launched its solar incentive programme in July 2012 and may install more than 4.6 GW of solar panels in 2013 (BNEF 2012b).

A second aspect deals with downstream growth strategies. Besides the focus on the manufacturing side, a shift is needed towards downstream growth strategies for installation and consumption that are driven by competitive PV and wind electricity pricing rather than incentives-based benefits. At the moment, wind farms offer low but positive returns, while PV installations are unattractive in China. The economics of wind and PV energy are still determined by financial incentives such as FiTs, in addition to capacity factors and capital costs, which means that more efforts should be spent in examining options to fully commercialize renewable energy downstream (CGTI 2012).

CONCLUSION

This chapter explains why a shift has occurred in China's renewable energy and climate change policies and how the renewable energy sector has developed, with a focus on wind and PV power sectors. Since the 11th FYP, Chinese leaders have perceived renewable energy as a key component and strategic industry in China's national policy, for three main reasons: energy security, market opportunities and climate change concerns. Given the scale and rapid growth of China's energy demand, China's leaders have become very much aware that the stability, security and sustainability of energy supply depends on active policies directly aimed at decreasing energy intensity and supporting the domestic renewable energy industry – and thus reducing the level of GHG emissions per unit of GDP. This trend towards strengthening the renewable energy sector reflects Chinese leaders' anticipation that renewable energy is and will be key to solving environmental problems, diversifying energy supply and establishing new global markets. Developing renewable energy is a crucial aspect to securing energy supply, realizing sustained and harmonious economic growth and transitioning towards a low-carbon society.

The development of the wind and PV sector has been staggering in terms of both its scale and its pace. PV and wind are among China's most important and rapidly changing energy sectors and are targeted in its most recent energy security and climate-related policies. Their strategic importance is reflected in the number of policy instruments exclusively created for enhancing industrial development during the last decade and by the increased cooperation and competition on renewable energy between China and Europe. The exploratory mapping of interactions between Europe and China illustrates six crossroads in this area, that is: Europe's example-setting function; technology transfer from Europe to China; China's role as the world's manufacturer of PV and wind power goods; the impact of Europe's declining demand for PV; China's outbound strategy; and the need for market rebalancing. Throughout these different patterns of interaction, European companies' demand for access to the world's fastest-developing PV and wind market is particularly salient.

In spite of numerous regulations, measures and strengthened cooperation, China still needs to overcome several challenges if it wants to keep up with the pace of development of the last few years. Firstly, the transmission capacity problem and the reluctance of grid companies to buy wind and PV generated power continue to be the main causes of the imbalance between installed capacity and actual produced power. Recently introduced measures demonstrate that the Chinese government acknowledges this problem. It is still too early, however, to measure the impact and effectiveness of

such measures on long-term prospects. The imbalance between national support for SOEs and their output, the need for innovation, the impact of tighter monetary policies and long-term macroeconomic prospects in China on the renewable energy sector require national, regional and international dialogue and cooperation. Other challenges, such as budget threats due to the continued economic turmoil in the developed world and the urgent need for global renewable energy market balancing, also require strengthened international cooperation to assure further development of the PV and wind sectors, which have become indispensable tools for securing energy supply and tackling climate change.

INTERVIEWS

Shanghai and Beijing, May–June 2009:

Business representatives: 11

Government officials: 7

Academics: 7

Brussels, May 2011–September 2012:

Business representatives: 9

Government officials: 2

Academics: 5

Total: 41

Note: Strict anonymity rules are applied to all interviewees due to the sensitive economic and political context of the research topic. In total, 41 semi-structured interviews were held during research visits to Shanghai and Beijing (2009) and Brussels (May 2011–September 2012).

NOTES

1. This requirement was included in the amendment of the REL in 2010. At first, grid companies curtailed electricity generated by renewables due to insufficient inter-regional grid connections (and the impossibility of reacting to the sudden influx of variable electricity) and the higher on-grid price for wind power than, for example, coal-fired power plants. To solve this problem, a revised REL took effect in April 2010, which 'obliges' grid companies to purchase a minimum amount of electricity from renewable energy sources.
2. At the end of 2006, the National State Estate Supervision Administration (NSES) under the State Council, a ministry that owns and controls all state-owned enterprises (SOEs), decided what would be defined as strategic industries. When an industry is strategic it means that the government will try to have full control over that sector and will limit foreign ownership.
3. Besides prices and transmission capacity, other factors such as equipment manufacturing,

technological innovation, public opinion and development in competing industries influence renewable energy development (Liu and Kokko 2010).

4. Irrespective of the trade deficit with China, the US was a net exporter of solar goods to China in 2010. In terms of PV energy-related trade flows to China, US imports in 2010 were estimated at \$1.4 billion, while exports were estimated to be between \$1.7 billion and \$2.0 billion. The EU had a negative trade balance with China in 2011; EU imports of PV goods, cells and modules are estimated at almost €15 billion and exports at around €619 million (GTM 2011).
5. Examples of rare earth elements used for manufacturing PV cells are indium and tellurium. Examples of rare earth elements used for manufacturing wind turbines are dysprosium and neodymium.
6. In 2011, Suntech Power's annual production capacity grew by 33 per cent to 2.4 GW; Trina Solar expanded by 90 per cent to 1.9 GW (CGTI 2012).
7. Foreign companies sell more on the Chinese market today than in 2005 because the Chinese market has become much larger and foreign companies started to set up joint ventures with Chinese companies as a way of fulfilling the local content rule.

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