

What drives investment in wind energy? A comparative study of China and the European Union

Abstract

Although the expansion of new renewable energy has been dependent on support in state policies, the research literature has scant focus on the political motivations for implementing policies to stimulate such development. The growth of wind power is an illustrative case of renewables expansion, as this is the most mature of the new renewable technologies. What can explain the rapid development of wind power production capacity in the EU and in China, despite their very different political systems and basic preconditions? Applying the method of *most-different systems design* in combination with document studies and interviewing, this article demonstrates how large-scale investments in wind power have come about through a specific set of political motivations backed by strong governmental support policies with similar main aims: security of energy supply, creating future-oriented industries and employment, and reducing greenhouse gas emissions and local pollution. These three factors together, broadly perceived, might also explain the political motivations that drive large investment in new renewable energy sources elsewhere.¹

Keywords

Environmental governance, renewable energy, wind power, China, EU, innovation.

1. Introduction

Transforming the world's energy systems to sustainable standards will require large-scale investment in renewable energy production (IPCC, 2014: 27–28). Today wind power technology is regarded as the most mature of the new technologies in renewables, with the potential to cover more than 20 % of global electricity demand by 2050 (IPCC, 2012: 539). Investment in wind power production may be taken as an illustrative case for examining what drives investment in renewable energy. Wind energy costs have decreased substantially in

¹ An earlier version of this paper has been published in *Energy Procedia*.

recent years, with grid parity² being achieved in a growing number of markets, among them Argentina, Brazil, Italy, Portugal and the UK (see Randall, 2012; World Energy Council, 2013: 11; IRENA, 2015b). The People's Republic of China (hereafter China) and the European Union (hereafter EU) have enormous potential for increased production of wind power, given their long windy coastal expanses, large mountainous areas and plains with high winds (EEA, 2009; Lu et al., 2009). Both have made considerable investments in new renewable energy³ – wind power, bio power and solar power in particular – in the past decade. Several studies have investigated the expansion of wind power production in Europe or in China (see Lewis, 2007; Blanco and Rodrigues, 2009; Weber, 2010; Ru et al., 2012; Zhao et al., 2012; Zhou et al., 2012; Korsnes, 2014; Dai and Xue, 2014; Li, 2015), including the effects of various support mechanisms (Lewis and Wiser, 2007; Butler and Neuhoff, 2008). Lema et al. (2011) focus on competition and cooperation between the wind industries in Europe and China, whereas Lema et al. (2013) discuss the impact of China's wind industry on the global wind industry. Analysing key participants' motivations for wind energy *innovation* in China, Urban et al. (2012) conclude that important drivers are concerns about energy security and economic growth, and more recently also climate change. These findings are confirmed by Boyd's document analysis (2012) of the political ideas driving renewables investment in China.

Still, few studies have to our knowledge conducted causal comparative analyses to reveal what has spurred the large-scale development of wind energy production in the EU and in China. The field of energy studies has few comparative studies and interdisciplinary studies, or studies conducted by political scientists and innovation scholars (Sovacool, 2014: 12, 13, 19, 20). This comparative interdisciplinary study addresses the overarching question of what types of politics can make policies on phasing in renewable energy achievable (see discussion of Sovacool, 2014: 21). Moreover, as pointed out by Aguirre and Ibikunle (2014: 375) there are few empirical studies of what influences renewables deployment, particularly worldwide. Several authors argue that political drivers are probably central in promoting renewable energy (e.g. REN21, 2014: 13), but studies on global samples of such political drivers have

² Defined as operation costs per unit of electricity production when all present and future costs are included, based on the lifetime cost: i.e. the costs of capital, finance, maintenance and operation.

³ New renewable energy includes wind, solar, bio and geothermal energy, but excludes large-scale hydro power and bio energy in the form of firewood, as hydro power has existed much longer on a commercial scale than the other renewable energy sources and wood has been used since ancient times

been inconclusive. Some argue that climate concerns are important (Aguirre and Ibikunle, 2014: 381–2), others that they do not matter (Marques et al., 2010: 6883); some studies hold that energy security is a key concern (ibid), others that it is not a major determinant (Aguirre and Ibikunle, 2014: 382). In a commentary article, Jacobs (2010: 30) emphasizes energy security, climate concerns and job creation as key drivers behind renewables investment worldwide. As Schaffer and Bernauer (2014: 25) note, qualitative case studies are useful for demonstrating whether decision-makers take structural factors into consideration in deciding about renewables support policies. Thus we ask: What political motivations may explain why the EU and China, despite their enormous differences, have had similar large-scale expansion of wind power capacity in the past decade? We find that a combination of three predominant political motivations has been crucial in driving the implementation of policies necessary to stimulate growth in wind energy capacity: security of energy supply, creating future-oriented industries and employment, and reducing greenhouse gas (GHG) emissions and local pollution.

These motivations will probably be the same as or similar to those that drive new investments in renewables in general, as politicians tend to seek to satisfy broader societal targets when they create and implement policies on renewables. Moreover, with the comparative method of *most-different systems design*, there is a high likelihood that the results can be generalized to other countries and regions. As renewable energy production has often been more expensive than technologies for producing e.g. coal and nuclear power, it has required various types of governmental support for deployment and innovation – like access to cheap loans, laws granting access to the electricity grid, and research and development (R&D) funding. Here we focus on the political motivations behind the creation of such policies in the EU (perceived as one entity + its member states) and China. Building more wind power installations does not necessarily translate into stimulating innovation in wind-turbine technology, but the two factors are interconnected: a domestic market for wind power can nourish a domestic industry with considerable potential for learning and ultimately innovation (Lewis, 2007; Lewis and Wiser, 2007). Such innovation can drive system costs further down, facilitating large-scale deployment and thereby energy-system transformation by becoming a cost-competitive ‘default’ technology. Support mechanisms are arguably essential for the early stages of a technology, to help it avoid the technological ‘valley of death’ and become commercial.

2. Method and data

We draw on historical comparative analysis and the *most-different systems design*. This design singles out for comparison cases that have similar outcomes on the dependent variable, but different values on all independent variables of relevance to the outcome except, ideally, for one or very few. Similar values on that single (or small set of) independent variable(s) should be able to shed light on or even explain the similarities in outcome. This method is useful for minimizing the number of possible causes, since independent variables where the cases score differently can be eliminated as single causal factors (although they may still be involved in multivariate causation) (Gerring, 2007: 143). We hold that since wind energy technology has needed various types of stimulating measures to expand, and energy policy is a heavily regulated field, the motivations of political leaders have been central for expansion of production capacity. These motivations can be measured from primary and secondary sources like interviews, public policy documents, reports, speeches and academic literature.

The EU and China have been chosen as cases of comparison, for several reasons. By definition, the EU is different from a nation-state – but as a political system/organization, it has strong federal features that make it comparable to national (not only federal) entities elsewhere. The EU is a relevant study object as regards wind power for various reasons: first, its member states have initiated large-scale investment in wind energy and have also fostered the leading manufacturers of wind energy equipment (GWEC, 2012). Second, the EU as a political organization is relevant because it is an organization where overarching climate and energy policies binding on the member states are created. Third, the EU has gained greater authority in the field of climate and energy (see Benson and Russel, 2014), although the ultimate power for making most decisions still rests with the member states. Recent expansion of wind-generation capacity in the EU is both a consequence of EU policies like the renewables requirements set for member states by the Renewables Directive (Directive 2008/28/EC) and of national ambitions, as the EU as such has no land, no legislative authority and also no funding for constructing wind farms. Thus, focusing on both the EU and its member states is justified in terms of causality here.

Several factors make China a pertinent case for investigation. First, since 2010, it is the country with the world's largest installed capacity for wind power production, although the EU, regarded as one unit, still ranks first. Second, Chinese wind energy equipment manufacturers now rank among the world's largest (Jiang et al., 2011; GWEC, 2015a: 38, 44; REN21, 2015: 71). Third, for relevant comparison of the development and deployment of a technology until recently deemed expensive compared to traditional energy sources, the cases selected for study should have a considerable potential for large-scale use of this technology. Both China and the EU have ample wind resources (Lu et al., 2009) and have the world's largest installed capacities. Thus they can serve as useful objects of study, influential cases particularly suited for shedding light on causal relationships of wider relevance (see Gerring 2007: 108).

The scope for generalization in the present study is potentially global: the causal relationship under scrutiny is in this type of design deemed valid across different regime types and levels of development. If we can isolate an operative cause of wind power expansion in both the EU (e.g. EU policies + EU28 policies) and China, that cause might be expected to apply to other political systems at national and international regional levels where there is high potential for renewable energy. There is, however, as George and Bennett (2005: 155–6) note, an inherent weakness with most-different case designs: cases with the same outcome might be discovered that do not have the same value on the variable(s) that survived the elimination procedure in the initial analysis. Therefore, in the discussion and conclusion section we assess whether the structural factors leading to the political motivations identified exist in other countries with large wind potentials and capacity for growth. We combine most-different systems design with causal analysis of influential cases using other case-study methods such as interviewing and document analysis to enable process tracing, as recommended by George and Bennett (2005: 156–60). This also meets the criticism of Gerring (2007: 140–2): that the most-different systems design method does not provide sufficient grounds for causal analysis in itself.

We focus on the period from around 1980 until 2015. In those years, modern wind-turbine industries were established in European countries and in China and, reaching technological maturity, started producing electricity in significant amounts (see Lew, 2000: 276; Kaldellis

and Zafirakis, 2011). Our dependent variable is installed wind power production capacity. The analysis is based on an extensive review of the literature, supported by 12 semi-structured interviews with professionals, experts and government officials connected to China's wind industry (autumn 2011), and one interview with a professional representing the European wind industry (spring 2013). Interviewees in China were identified through online research, industry association lists and trade statistics and, most importantly, the snowball method. The underlying reasoning behind selecting particular interview candidates was to map the opinions of central actors in order to draw a representative picture of the motivations behind the growth of China's wind industry. In order to confirm or contrast hypotheses based on the other data, we later (2013) contacted an interviewee representing the European wind energy sector. Concepts and methods are drawn from political science and from innovation studies.

3. Wind power in China and in the EU

3.1 The EU

In Europe, the market for wind power grew steadily from the 1980s onwards. Denmark, with no hydroelectric power production and a populace negative to nuclear energy, was the first to invest in commercial-scale wind power. The introduction of explicit support mechanisms spurred the rapid expansion of Danish wind power in the 1980s (Pettersson et al., 2010: 3117–8). Elsewhere in the EU, wind power expanded markedly after the introduction of feed-in tariffs (FiTs),⁴ in particular the 1990 electricity feed-in law (*Stromeinspeisungsgesetz*, StrEG) and a package of other measures in Germany in the 1990s. As this system, combined with other support mechanisms, made wind power the most attractive renewables technology in Germany at the time, most German expansion of renewable energy that decade came from this energy source. This development continued with Germany's renewables law of 2000 (*Erneuerbare-Energien-Gesetz*, EEG) (Jacobsson and Lauber, 2006: 267–8). Since 2000, other EU countries have also launched a range of support mechanisms to promote investment in wind power in order to expand their production capacity – especially Spain, the UK, France and Italy (REN21, 2015: 71). The European Union has also made renewable energy a core strategic priority. Measures have been launched to spur the production of renewable energy –

⁴ Feed-in tariffs are technology-specific subsidies that ensure that the producers of renewable energy are paid a specific price per unit of electricity produced for a long period, typically 20–25 years, to enhance innovation and investment in renewable energy sources. These have usually been combined with non-discriminatory granted grid access in order to facilitate production.

notably, the 2001 Renewable Electricity Directive (Directive 2001/77/EC)⁵ and the 2009 Renewables Directive.⁶ The latter sets binding national targets whereby member states must expand their production and use of renewable energy so that by the year 2020, 20% of energy consumed in the EU will stem from renewable sources (Commission, 2009; 2010). The choice of support mechanisms and strategies is left to the individual member states, with some restrictions.

To stimulate wind-capacity investment, most EU countries have chosen FiTs or similar systems, most notably Germany and Spain, but some have other main support mechanisms. For example, the UK and Sweden employ renewable portfolio standards (RPS)⁷ (REN21, 2012: 70–73; 2014: 89). The EU has launched measures for stimulating wind-technology innovation and development. Wind technology is among the technologies chosen by the European Commission (hereafter: Commission) for focus in the European Strategic Energy Technology Plan (SET Plan), which includes the European Wind Initiative (EWI). The SET Plan is the ‘technology pillar of EU’s climate and energy policy’ (Commission, 2009b), while EWI is the result of a joint effort by the European Wind Energy Technology Platform (TP Wind), the Commission and member states (EWEA, 2010: 8). EWI is aimed at strengthening wind-related R&D through investments of approximately EUR 6 billion over a 10-year period in activities such as testing facilities for new wind turbine systems and prototypes for offshore structures (Commission, 2009b; 2010). The goal is for wind energy to supply the EU countries with 20% of their electricity needs by 2020, and 33% by 2030, in addition to creating 250,000 new jobs in the wind industry by 2020 (EWEA, 2010: 6, 2012d: 33). These policies are probably at least partially a result of political pressure. Szarka (2010) has found that advocacy coalitions of various interests have had major effects on wind power policies in Denmark, France, Germany, Spain and the UK. Moreover, Ydersbond (2014b) documents

⁵ Full title: Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity from renewable energy sources in the internal electricity market.

⁶ Full title: Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. Brussels, European Commission.

⁷ Renewable portfolio standards, or ‘green certificates’, are certificates showing that a certain amount of electricity from renewable energy has been generated, typically 1 certificate per megawatt hour (MWh). Companies that distribute electricity are obliged to have a certain share of electricity from renewable energy sources in their portfolio, and are therefore required to buy these certificates from the power producers. This gives the power producers more money to invest in the production of renewable energy.

that advocacy coalition lobbying across political levels may have been crucial to the ambitiousness of the Renewables Directive.

Policies on wind power have had profound impacts: in 2012, total EU production capacity from wind energy passed the milestone of 100,000 megawatts (MW) and totalled 128,752 MW by the end of 2014 (EWEA, 2012; 2015: 6). This is 14.1% of total EU generation capacity, and would in a normal year generate around 284 terawatt hours (TWh) of electricity, covering 10.2% of all EU electricity consumption (EWEA, 2015b: 3).⁸ In Denmark, Germany, Ireland, Portugal and Spain, wind power constituted more than 10% of gross final electricity consumption (EWEA, 2013: 11). The International Renewable Energy Agency (IRENA, 2015a), estimates there were 319,600 persons employed in the EU wind industry in 2013. This is a high-tech industry where European companies like Vestas, Siemens, Enercon and Gamesa are world leaders in R&D in new technologies (REN21, 2013: 50):

[...] lots of renewable energy in general, but particularly wind energy is a European success story, the pioneering Spain, Germany and Denmark rule the world in terms of not just the finished turbines, but also in terms of components, in terms of expertise, in terms of the development of wind farms and the construction of wind farms [...] (interview EWEA, 2013).

Today the frontier of wind power technology is moving offshore: as of 2014, offshore wind covered approximately 1% of EU's electricity consumption (EWEA, 2015a: 10). The UK, with the EU's greatest offshore wind potential, has become a particularly ambitious facilitator. As of 2015, it has a total estimated capacity of 5,054 MW offshore (UK Wind Energy Database, 2015). Despite the financial crisis, installed capacity in the EU has generally shown a steady increase (EWEA 2015: 9). However, the crisis might have negative impacts on future growth in large-scale wind energy, in particular in countries hard-hit. Some governments have changed their support regimes and made them less predictable, which has led to investor uncertainty, less favourable investment conditions and lower deployment of wind energy (GWEC, 2014a: 48; EWEA, 2015b: 3,4). This was voiced by our interviewee from EWEA: 'Clearly, a map of the economic crisis and a map of where wind energy is being built out more or less fast is quite similar' (interview EWEA, 2013). Figure 1 shows important policies on renewable energy, and capacity growth.

⁸ Installed capacity of electricity measures the intended technical full-load of a unit, over a given amount of time, usually measured in megawatts (MW). Megawatt hours (MWh) is the actual production of electricity from that unit, per hour. One terawatt equals 1000 gigawatts, and one gigawatt (GW) equals 1000 megawatts (MW).

Figure 1: [about here]**3.2 China**

China has pursued a double strategy of securing electricity generation from grid-connected turbines while simultaneously building up a manufacturing industry. Manufacturers began testing prototypes from 1985, but failed to commercialize them (Gan, 1998). The first subsidies for promoting wind power in China came with rural electrification programmes through small wind-farms in Inner Mongolia in 1986, where imported turbines were used. In the 1990s, the Ride the Wind Programme was introduced, and since the turn of the millennium various policies have been launched (see Figure 2) (Lew, 2000; Ru et al., 2012). Current support policies for solar and wind power include tax credits, FiTs, preferential land-use policies and low-interest loans (Jiang, 2011; CGTI, 2012: 13). The authorities have also implemented other policies; for instance, China's Renewable Energy Law (ReLaw), which entered into effect in 2006, requires power-grid operators to connect renewable energy production facilities to the grid, and mandates power companies to purchase renewable energy produced in their area (Government of China, 2005).

China has increased its installed wind power capacity from a few turbines some twenty years ago to 114,763 MW as of the end of 2014, making it the leading wind market (GWEC, 2015). In 2013, this capacity generated 140 TWh, or 2% of total electricity generation in China (Pengfei, 2014). Since 2006, the wind industry has been growing almost exponentially: by 2012, capacity exceeded that of five years earlier 24 times over (Interfax, 2012; Qiao, 2012). Most of this electricity is produced in the northernmost regions of China, whereas the major load (consumption) centres are located along the eastern coast. Therefore, much of the power produced must be transmitted long distances,⁹ entailing major challenges to electricity generators, wind-equipment manufacturers and the two grid companies, State Grid and Southern Grid. Introducing large amounts of intermittent power into the grid requires careful

⁹ It is estimated that slightly more than half of all the electricity generated from wind in 2015 in China must be transmitted on long-distance lines, with the rest consumed locally (Ni and Yang, 2012: 38).

planning of a type that has been in short supply in China, as noted by several studies and reports (e.g. IEAwind, 2012). The grid infrastructure is the major bottleneck as regards production of wind energy: if it is to satisfy present and future needs, it will have to be developed and expanded to transport greater amounts of power, and managed more flexibly (see GWEC, 2012; Li et al., 2012a; Yang et al., 2012; Zhang et al., 2013a). The national government has set a target of 200 GW of installed capacity by 2020 (Li et al., 2012b). In fact, according to China Wind Power Outlook 2012, by 2020 capacity could soar to between 200 and 300 GW (Li et al., 2012b). However, the industry is not yet mature and Chinese-made wind turbines have a poor track-record compared to those manufactured in Europe. Moreover, China lacks skilled personnel; and there have been accidents linked to inadequate training of employees and poor management (interview Azure International, November 2011). With the rapid development of the sector, this may change. Figure 2 shows how wind-capacity expansion has been accompanied by key policies on renewables.

Figure 2: [about here]

4. Driving forces

The literature in political science and economics mentions several factors that might motivate political leaders to stimulate wind-capacity growth (see e.g. Jacobs, 2010; Fornahl, 2012). With China, likely political motivations can include poverty reduction, exploitation of macroeconomic comparative advantages like extensive manufacturing experience, using port infrastructure and access to cheap input factors such as labour, as well as increasing the number of market actors to enhance competition. In the EU, likely political motivations for investing in wind energy might include the desire to replace nuclear generation capacity, particularly after the Chernobyl and later the Fukushima nuclear accidents, and employing their mature high-tech industries. However, since the EU + EU28 and China score very differently on these variables, all must be ruled out in the elimination procedure of the most-different systems design as necessary historical motivations driving wind energy growth in the past decade. Instead, we argue that the similarities in outcomes are due largely to three predominant political motivations, described in detail below: greater climate awareness and

reduction of local pollution, improving energy security, and creating jobs and boosting economic growth through high-tech leadership (see Table 1).

Table 1: [about here]

Sources: Commission, 1997:3; 2008; 2009a; 2009b: 2; 2011a; 2012; 2014c: 12; 2015b; NDRC, 2007: 11; State Council Information Office, 2007; Jacobsson and Lauber, 2006; Jacobs, 2010; Ngan, 2010; interview Bloomberg New Energy Finance, 2011; Boyd, 2012; Fornahl et al., 2012: 845; HM Government, 2013; interview EWEA, 2013; Zhang, 2013b:350-351; Wu, 2014; World Nuclear Association, 2015.

4.1 Greater climate awareness and reduction of pollution

4.1.1 The EU

Climate awareness as a driver for investing in renewables gained in importance especially from the late 1990s, after state leaders had completed the Kyoto negotiations. There the Commission negotiated as one bloc on behalf of the EU member states, and the EU sought to achieve global environmental leadership by committing itself to large obligations to reduce GHG emissions. Since then, EU has aimed at being a global environmental leader (see Oberthür and Roche Kelly, 2008), launching various policies, not the least its Climate and Energy Package, which includes a strengthened version of the 2003 EU Emissions Trading System (EU ETS), as well as the Renewables Directive and directives on CCS and a revised directive on fuel quality. Ambitious targets have been set, like reducing GHG emissions by 80–95% by 2050 compared to 1990 levels (Commission, 2011a: 3). Studies indicate that the EU has made its member states more ambitious regarding renewable energy (see Schaffer and Bernauer, 2014; Ydersbond, 2014a: 20). In October 2014, the member states agreed on new overarching climate and energy targets for the period 2020–2030, with at least 40% reduction in GHG emissions, at least 27% share of renewable energy at the EU level and an indicative target of at least 27% energy efficiency (Council, 2014). An overarching motivation was to have a credible and workable negotiating stance prior to the December 2015 global climate negotiations in Paris.

Several member state governments have highlighted GHG mitigation and economic restructuring towards a ‘green economy’, also before EU launched its policies. For example, Germany aims to rebuild the economy to make it sustainable (BMU, 2012). Moreover, Denmark has stated that *all* energy should stem from renewables by 2050. Sweden has set the target that its energy system is to be carbon-neutral by 2050. Germany has declared that that at least 80% of its electricity should come from renewable sources by 2050, as should 60% of final energy consumption; and that GHG emissions should be reduced by 80–95% (MD, 2008; Bundesregierung, 2010; Naturvårdsverket, 2012; BMU, 2011; DEA, 2014). Climate is declared a major concern in various EU documents highlighting the importance of renewables growth (e.g. Commission, 2011a). This is confirmed by our EU industry interviewee, who also underlined that other factors were important:

One of them, of course, environmental reasons, but not singularly, there is also a lot of security of supply, the EU imports 70% of its energy needs. There is also an old thing about jobs and leadership, it is an industry where EU leads, and there are lots of considerations about hedging against volatility of fossil-fuel prices, so there are many considerations that are very explicit (interview EWEA, 2013).

Our findings are confirmed by other research (e.g. Jacobsson and Lauber, 2006; GWEC and IRENA, 2012: 26).

4.1.2 China

The Kyoto Protocol exempts China from commitments to reduce its GHG emissions. In international climate negotiations, China’s general stance has been that it should not be required to restrict its GHG emissions now, because it is still to be considered a developing country. Climate awareness has been increasing in China, as Economy (2010) and Stensdal (2014) point out. From 2007 onwards, climate change has become a national priority and mitigation issues are an important target in long-term central planning. The government has launched several policies as regards climate change. Most prominent of these is the *Mid- and Long-Term Development Plan for Renewable Energy in China* of 2007, whereby non-fossil fuels are to cover 15% of final energy consumption by 2020 (NDRC, 2007; Economy, 2010). Stensdal (2014: 130) finds that these developments have been stimulated by an expert advocacy coalition consisting of various groups, including national and international environmental nongovernmental organizations (ENGOS), scientists, and members of the National Advisory Committee on Climate Change (NACCC).

Since 2012, China has been the world's largest emitter of GHGs in absolute terms, and has recently surpassed several Western countries (including the EU average) in terms of emissions per capita (BBC, 2014). Massive problems with pollution and environmental degradation at the national and not the least local level are also likely to have contributed to the greater focus on environmental issues in China. They cause severely increased mortality and morbidity, spurring considerable popular protest (Liao et al., 2010: 1879; Shapiro, 2012; CGTI, 2014: 23–4). 'We will resolutely declare war against pollution as we declared war against poverty', Chinese Premier Li Keqiang proclaimed at the opening of the Parliament in March 2014 (Reuters, 2014). In a 2014 joint announcement with the USA, China for the first time announced official targets and responsibility in combating global climate change, and agreed to halt the increase in its national emissions by 2030 (White House, 2014). Also other studies (e.g. Boyd, 2012) note climate concerns as an important driver for renewables policy in China.

4.2 Improving energy security

4.2.1 The EU

In contrast, EU energy consumption has basically stabilized, and the energy intensity of its economy is declining significantly (Commission, 2014b: 2). Few nuclear power plants are currently under construction. Scepticism towards nuclear power has increased, accelerating especially in the wake of the 2011 Fukushima nuclear meltdown (see Commission, 2012b: 6). Member state coal consumption has generally decreased over the past two decades, with some recent resurgence due to low world coal-market prices, caused mainly by the 'shale gas revolution' in the USA combined with low CO₂ quota prices (Commission, 2012a). Still, EU countries remain heavily dependent on the import of fossil fuels, including coal: more than half of EU energy consumption is covered by imports from outside (Commission (2014b). Commission forecasts project growth in this relative dependence caused by lower consumption and higher prices (Commission, 2014d: 93).

In the course of the past decade, the three Ukraine–Russia crises, severely threatening energy supply security in several Southern and Eastern EU member states, have moved security of

supply to the top of the political agenda. These situations have contributed to making diversification of energy supply an important target also in the EU and its member states (see Duffield, 2012; Commission, 2014b). Various measures have been undertaken to enhance energy security, partly in highly national-inspired ways by the member states – such as expanding energy import by constructing gas pipelines from Central Asia, Russia and Norway; building LNG terminals; reducing energy consumption; and stepping up domestic energy production from various sources (see Müller-Kraenner, 2008), and increasing domestic production of renewable energy such as wind power (see Bundesregierung, 2015; DEA, 2014; Ydersbond, 2014a). Numerous strategic EU documents highlight the importance of expanding renewable energy in order to improve security of energy supply (see Commission, 2011a; 2011c; 2014c). Furthermore, enhancing electricity grid capacity domestically and between states is essential for ensuring a more stable energy supply (Commission, 2015a). This is also a key infrastructure issue that the EU emphasizes in seeking to create a single internal market for electricity and gas, as in the Commission's energy infrastructure package (Commission, 2011b). Several other studies (e.g. Nilsson et al. 2009) also identify energy security as a key driver for ambitious renewables policy at the EU level.

4.2.2 China

Chinese energy consumption has risen rapidly in the last decade, as a result of double-digit economic growth until recent years, population growth and urbanization (Jiang and Lin, 2012; WB, 2014). This economic growth has made China an 'emerging economy', although formally not a 'developed country'. China is currently the world's largest energy consumer, with its energy supply still based primarily on fossil fuels – coal and oil in particular (Wu, 2014). The rapid rise in energy consumption has made China increasingly dependent on energy import (Müller-Kraenner, 2008; Andrews-Speed, 2012: 140; EIU, 2012; Jiang and Lin, 2012; Mathews and Tan, 2014). Since 2009 China has been a net importer of coal, in 2012 importing 8% of its total coal consumption. To reduce dependency on energy from abroad, Chinese authorities aim to diversify the energy supply, to be achieved in various ways – like seeking new supply routes and sources of petroleum, constructing new gas pipelines, and increasing the production of nuclear power (IEA, 2012; EIA, 2014). Another part of this strategy involves creating domestic industries and markets for renewable technologies like wind and solar power, to achieve large-scale expansion in domestic renewables (see Klare,

2008; Cao and Bluth, 2013; Mathews and Tan, 2014). This strategy has had effect: by 2014, China had become the world's largest investor in renewable energy, and was number 1 in the world in adding capacity for wind power, hydropower, solar PV and solar water-heating (REN21, 2015: 20). Several recent studies confirm this, and hold that increasing energy security is a main concern for stimulating renewables growth in China (see Bambawale and Sovacool, 2011; Conrad and Meissner, 2011; Urban et al., 2012: 112, 121; Zhang et al., 2013a; Mathews and Tan, 2014).

4.3 Boosting the economy and creating jobs

4.3.1 The EU

In 2011, the Commission (2011c: 5) noted: 'European companies currently dominate the global renewable energy manufacturing sector, employing over 1.5 million people, with a turnover of over EUR 50 billion.' If such growth continues, according to the Commission, this can create another million jobs and triple turnover in the sector. The EU aims to become a global leader in renewable-energy technology innovation, as stated *inter alia* in its Energy Roadmap 2050 (Commission, 2011a). Being the first in a new technology may entail various advantages for a region: its companies can gain market shares and develop specialized expertise that can yield additional benefits, creating efficient delivery systems at an early stage, and establishing brand names and solid reputations (see Teece, 1986). Studies have documented that Danish firms have become market leaders because of their first-mover advantage (Kamp et al., 2004; Lewis and Wiser, 2007). Wind energy investments in Germany and Denmark have long been motivated by leadership ambitions in the field, the desire to boost their economies and to create jobs (see BMU, 2012; Schmidt, 2012). The creation of 'green' jobs also appears to be a key aim for EU member states in launching ambitious policies to stimulate the development of renewables capacity in general, as in Germany and Denmark (EFK, 2012; Bundesregierung, 2015).

4.3.2 China

Also Chinese political leaders appear motivated by concerns for the economy and for job creation (Beebe, 2011). Several interviewees reported that job creation was an important

motivation for developing the wind industry in China. As one interviewee from Bloomberg New Energy Finance explained (2011):

From the government perspective they are going to have a huge employment problem, and a huge social stability problem, unless they can create new sectors that create jobs, and new avenues to ensure economic growth. This is one reason the government has supported China's wind industry.

China, the 'workshop of the world', has considerable experience in manufacturing all kinds of goods, and Chinese companies are generally keen to supply an item whenever a new demand arises. Furthermore, the government wants the country to be a global 'greentech' leader,¹⁰ and views investment in renewable energy as an historic opportunity to gain global market shares in renewable energy infrastructure production (e.g. Zhang et al. 2013b: 351). Over the past decade, the Chinese government has launched a range of policies to stimulate growth and innovation in wind power-related manufacturing and to enhance the capacity of wind power production. In 2010 it elevated renewable energy technologies to one of seven key strategic policy areas deemed vital for ensuring economic development, facilitating innovation, and promoting domestic technology development. This plan entails investing some USD 231 billion in the wind sector alone between 2011 and 2020 (Pan et al., 2011: 14).

As in Europe, wind investment appears to be an efficient labour-market strategy. Between 2006 and 2010, growth in the industry created an additional 60,000–81,400 jobs directly for tasks such as operating wind turbines, and 32,000 jobs a year indirectly (Pan et al., 2011: 14). In 2013 there were 502,400 people employed in China's wind industry, according to the International Renewable Energy Agency (IRENA) (2015a: 6). With a working population of more than 915 million persons (South China Morning Post, 2015), 502,400 is a low share of the total workforce, but the figure is noteworthy, making China's wind industry the largest in the world (IRENA, 2015a: 6). In 2014, USD 83.3 billion was invested in renewable energy in China (REN 21, 2015: 81) – a new record. According to estimates from IRENA (2015a: 4–8), China also has the largest number of employees in the world in solar PV, solar heating and cooling, small hydropower and large hydropower: 'China has firmed up its position as the leading renewable energy job market with 3.4 million employed' (IRENA, 2015a: 9). This rapid expansion has not come without new challenges. For example, there has been

¹⁰ Greentech: technologies, products and services that deliver benefits to users of equal or greater value than those of conventional alternatives, while limiting the impact on the natural environment as well as maximizing the efficient and sustainable use of energy, water and other resources (CGTI, 2012: 9).

overcapacity for production of some renewable technologies in China, including wind-turbine manufacturing and manufacturing of solar photovoltaic panels (Zhang et al., 2013b: 343; Zhang et al., 2014: 908; GWEC, 2015a: 40; REN21, 2015: 62).

5. From technology transfer to indigenous innovation

The growth of wind energy in China and in the EU has not occurred entirely separately: the wind sectors in both places have had many mutually beneficial interactions.¹¹ For instance, the Clean Development Mechanism, funded amongst others by several EU countries until 2012, has helped to reduce the cost of additional wind power installations in China (Lewis, 2010). Furthermore, China's wind-turbine industry has been based on technology licensed from abroad, predominantly from German firms. Such licenses tend to be expensive, and the revenues are often invested in further R&D to create new competitive turbines – making it harder for Chinese market entrants to develop the best new technology on their own (Korsnes, 2012). European wind companies have established production facilities in China because of a law in effect from 2004 to 2005 that required all turbines to consist of at least 50% components made in China; from 2005 to 2009, there was also a local content requirement of 70% (Korsnes, 2014). Thus far, mergers and acquisitions between companies have not played a major role, but for some Chinese firms this has become an important strategy for tapping into global innovation networks (Ru et al., 2012; Silva and Klagge, 2013; Chen et al., 2014). For example, China's Goldwind bought a majority share of Vensys' stocks in 2008, and from then on participated more in R&D activities in Germany, where Vensys has its home base.

Other factors that have stimulated technology transfer include reduced value added tax, extra funds for wind-turbine R&D, and collaboration between (some) research programmes in China and Europe for developing wind technology (Lewis and Wiser, 2007; Lewis, 2013). To date, Chinese turbines have had a poorer track-record and lower reliability than their European counterparts. China has now begun investing more in domestic R&D, leading Ru et al. (2012: 58) to conclude: 'The innovation mode in China began with imitative innovation, then transitioned to cooperative innovation, and has more recently set its sights on attaining

¹¹ A general principle in comparative studies is that the units of comparison must be independent of each other (Lijphart, 1975, p. 171). Here, there are clear connections between the wind industries in the EU and in China. However, since such interaction has occurred mostly at the company level, we believe our general analysis remains valid.

truly indigenous innovation.’ Here, ‘indigenous innovation’ refers to Chinese companies owning the intellectual property, and potentially being able to design pioneering wind-turbine technology in the future.

China’s grandiose entrance in the world renewables markets has had major consequences: As noted by Hearps and McConnell (2011), The Economist Intelligence Unit (2012), and others, the entry of Chinese manufacturers in renewable technologies like wind turbines and solar cells has pressed down global prices, due to economics of scale and harder competition. The relatively rapid price decrease has made these renewable technologies easier to access; and with grid parity rapidly approaching, further investment in the whole sector is spurred by the increasingly bright future prospects (see IRENA, 2015b). Lema et al. (2013: 39) conclude: ‘[...] China is transforming the global wind power industry and challenging Western leadership in this green industry, but also providing new opportunities for cooperation.’

6. Discussion and conclusions

This study has explored why the political leaders in the EU + EU28 and China, despite their differences, have opted for large-scale investment in wind power during the past decade. Employing the method of most-different systems design combined with other case-study methods, our analysis has indicated that three factors shared by the EU and China have influenced the decision to establish national wind industries, and their goals for wind-generation capacity. These three factors are: enhancing energy supply security, creating a domestic industry that provides future-oriented jobs, and taking action on mitigation of GHG emissions and local pollution.

One way of investigating whether these drivers are important is to compare with other countries with sizeable wind power potential and expansion, like the USA, Russia, Brazil and India. Turning first to the basic energy statistics of these countries comparable in size to China and the EU, we find some indications to support our claim. As shown in table 2, CO₂

emissions in China, EU27,¹² the USA and India are all fairly high, and these countries all have large installed wind power capacity. They also have a relatively high proportion of coal-power generation. Further, statistics on import dependency show that these heavily import-dependent countries are the same ones that have invested in wind power. These figures prove that there are similarities amongst the large wind power countries. High import dependency and large GHG emissions are, of course, not enough to explain high growth in wind energy capacity, but they may be structural factors that serve to motivate political leaders.

Table 2: [about here]

Sources: GWEC, 2014a and b; IEA, 2014; OECD, 2014.

Moreover, many studies indicate that all three arguments posited in this article have had impacts on sustaining the wind energy sectors of the USA and India (see Yergin, 2006; Bomberg and Super, 2009; Bang, 2010; National Academy of Engineering et al., 2010; AWEA, 2012; Bolinger, 2012; GWEC, 2012: 65; GWEC and IRENA, 2012; MNRE, 2012; 2011). These motivations are especially strong when regions or states want to position themselves as environmental leaders, as is the case with the EU and the US state of California. Thus, all three groups of reasons appear well-supported by evidence from the literature.

But – are all these factors equally important? And how do they relate to each other? GHG concerns were not a major issue for most countries until the late 1990s, whereas energy security concerns seem to have varied with countries' differing energy needs as well as the global geopolitical situation. Boosting the economy might also vary with the differing challenges facing various countries, states and regions. Creating more jobs is normally seen as a pressing political issue when unemployment rates are high or expected to grow. Whether one motivation is ultimately more important than another is very hard to document, as all the motivations are frequently mentioned together in recent official documents, political speeches and elsewhere explaining the rationale for launching of ambitious policies on wind energy

¹² EU27 before Croatia joined, making the EU a union of 28 member states.

capacity growth. For instance, some analysts argue that energy security has been the most important internal driver behind China's renewable energy expansion (e.g. Stahl and Schioppa, 2013; Mathews and Tan, 2014). In this article, however, we seek to demonstrate that the three identified factors *taken together* are major motivations behind wind power developments in China and the EU, and probably also for investments in new renewable energy in the world in general. Instead of giving priority to only one or two concerns, we hold that all three must be taken into account to understand the political motivations behind renewable energy development at the global level historically. This may also explain why some countries seem reluctant to develop more renewable energy, despite ample renewable energy resources. Our findings should be tested by further studies employing various methods, a larger sample and additional data.

Further, although political motivations are probably the ultimate drivers, various societal factors influence the pace and efficiency of policies that have been launched. These include permissions procedures for new wind-farms, the electricity market price, and the availability of skilled workers. Other data indicate that support may be reduced when political leaders see promoting renewables as 'expensive', as in times of economic crisis (e.g. interview EWEA, 2013). This can happen regardless of the positive effects of such policies on employment, how much a country spends on subsidizing competing energy sources, and the actual long-term economic effects. Thus, the future of renewable energy will also be influenced by what political leaders see as being most economic, politically correct and popular among domestic constituencies – as well as by the desire to 'look good' on the international arena in climate negotiations.

The most important new renewable energy sources – wind and solar photovoltaic – are intermittent. Although they complement each other to some degree, profound infrastructure adaptations will be required for them to become the dominant energy sources. While they increasingly achieve grid parity, phasing them in will depend on political priorities until the infrastructure issues are solved. Over time, such priorities may become less important, especially if local production and storage of energy become widespread. As Yergin (2014) has shown, politics are volatile, and the energy policies implemented to follow up national political decisions have shifted considerably in the past decades – and in unexpected ways.

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Appendix A: [about here]

Appendix B: [about here]

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