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Towards a Political Economy Framework for Wind Power: Does China Break the Mould?

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Towards a Political Economy Framework for Wind Power

Does China Break the Mould?

Michael R. Davidson, Fredrich Kahrl, and Valerie J. Karplus

13.1 INTRODUCTION

Wind power is considered one of the most cost-effective options for reducing carbon emissions from the global electricity system. However, achieving higher penetrations of wind energy presents a number of unique development and integration challenges. Most of the existing literature has focused on general solutions to technical engineering and economic problems, as well as the design of dedicated policy support. There has been far less focus on the political economy of wind development, which involves the features of countries, regions, and systems that shape incentives for developing and integrating wind power. Given that this broader context mediates the effectiveness of dedicated technical and policy approaches to promote wind, this is an important gap.

Drawing on global experience, this chapter develops an analytical framework for understanding the spectrum of political economy conflicts that arise when introducing and scaling wind power within an electricity system. We apply this framework to China, a country that has very different electricity sector institutions from those found in most other countries. We argue that China's wind development and integration challenges can be understood through a general political economy framework, and show how high levels of wind energy curtailment in China are an expected result of clashes among actors and interests.

13.2 BACKGROUND: WHY DEVELOP A POLITICAL ECONOMY FRAMEWORK FOR WIND

The physical properties of wind energy—its variability, forecast uncertainty, and location relative to demand centres—create technical challenges for existing systems. Electricity systems have historically been designed to accommodate generation over which operators had greater certainty and more control. Accommodating wind requires revisiting established planning and operational procedures, challenging prevailing political and economic authorities under institutional arrangements.

Similar to other large-scale technological changes, efforts to increase the share of wind energy on electric grids must confront existing political and economic institutions. In the case of wind, such political economic conflicts are numerous. Although they have been examined in a handful of contexts (Fischlein et al. 2010; Kahrl and Wang 2014; Krishna et al. 2015; Lehmann et al. 2012), analysis of the political impediments to wind development and integration tends to focus more on public acceptance than on institutional design (Haggett 2008). The redistribution of economic rents that ensues can lead to a reshaping of political influence (Jacobsson and Johnson 2000), motivate incumbents to minimize adverse impacts through political channels (Stigler 1971), and at its outset prompt resistance that slows the pace of institutional and technological change (Mahoney and Thelen 2010). Technically efficient wind integration strategies, such as new market designs or enlarging balancing authority areas, may be slowed, altered, or dropped altogether when they challenge established practices, norms, and interests.

Wind power development interacts with ongoing transformation efforts in electricity sectors worldwide. Since the 1980s, a number of countries have restructured their electricity industries, transitioning from regulated, vertically integrated natural monopolies to unbundled ownership structures with competition in the generation and, in some cases, retail segments of the industry. Each jurisdiction has its own unique pathway defined by prior institutional context and proximate justifications for reform, which affects the degree to which market competition can be facilitated. Costs, economic transfers, and economic behaviour associated with wind development and integration occur, and must be understood, within these unique institutional contexts.

Developing countries share some similarities in approaches to restructuring. Typically, countries with a rapidly expanding 'green-field' electricity system and expected high demand growth will emphasize attracting capital over efficiency gains that result from competition. Public ownership is more prevalent and may be retained even following unbundling. Providing electricity services at prices affordable to low-income populations complicates liberalizing retail tariffs and may hide inefficient cross-subsidization. Weak or resource-limited government institutions for administration, information collection, and verification can hinder cost-effective regulatory design and implementation (Jamasb et al. 2005; Williams and Ghanadan 2006).

One might expect China to be different from other emerging economies because of its unique institutional history, which before market-oriented reforms in 1978 consisted of a planned economy layered on top of a largely federalized system of governance established over centuries of dynastic rule. But is China really different? The extent to which China's experience with wind energy in its electricity system reflects a more universal set of political economy challenges is ultimately an empirical question.

13.3 POLITICAL ECONOMY FRAMEWORK FOR WIND POWER DEVELOPMENT AND INTEGRATION

We develop a framework to probe institutional bottlenecks affecting the development of wind electricity. We distinguish between political institutions (the degree of centralization and regulatory philosophy) and economic institutions (industry structures and approaches to price formation). Our analysis sheds light on how alternative configurations of political and economic institutions, through their influences on actors and interests, lead to different decisions—and thus outcomes—for wind investment and integration (see Figure 13.1).

Our framework is rooted in a broader literature that evaluates the impact of political and economic institutions on the rate and direction of transition within large-scale fixed infrastructure systems with long lifetimes (Markard 2011). We adopt the Northian definition of institutions as 'humanly devised constraints' that shape interaction and can be both formal and informal (North 1991: 97). We develop our framework with examples from a wide

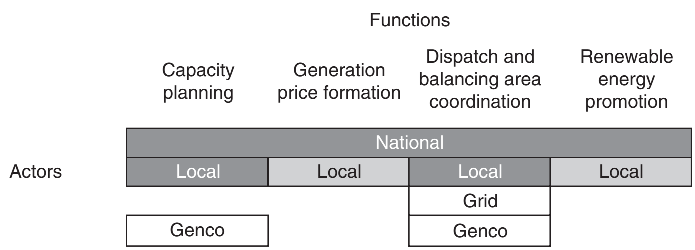

Figure 13.1. Economic and political actors in key wind sector functions in China.

Note: National, national government agencies; Local, local government agencies; Grid, grid companies; Genco, generation companies. Within government, dark shading indicates primary role, light indicates an oversight role.

Source: Authors' compilation.

range of contexts, mainly in the US and Europe. We then ask whether this framework holds in the case of China, drawing on rich experience in wind development witnessed in recent years.

13.3.1 Political Institutions

Political institutions comprise the first dimension of the framework. Here, we define political institutions as governmental roles housed within political bodies, and the vertical and horizontal relationships that connect them. Broadly, these roles can be divided into policy and regulatory roles. Policy roles include treatment of state and non-state entities, long-term plans for electricity reforms, environmental and energy policy design, and in some cases pricing, which has implications for the design of renewable energy incentives. Regulatory roles typically involve implementing the policy regime in a fair and efficient manner, for instance by policing abuses of market power, determining costs, and overseeing pricing, planning, dispatch, and other electricity sector functions.

Countries vary in size, network structures, and resource endowments, which affect the viability of creating markets and influencing government priorities (Jamasb 2006). In general, countries with well-developed electricity systems have different goals from those still in early stages of development: the former may be aiming to optimize efficiency and provide greater choice to market participants, whereas the latter are typically trying to attract private capital to an over-burdened publicly funded system. The institutions and ideological basis for creating complex markets are also more developed in the former, whereas the latter may not share the basic regulatory premise of valuing reduced government intervention (Williams and Ghanadan 2006).

13.3.1.1 Governance of Power Systems: Dimensions of Diversity

We consider four distinct dimensions in the governance of power systems, with systems lying on a spectrum between extremes within each dimension (Table 13.1).

First, countries and supranational bodies differ in the extent to which policy and regulatory functions are distinct and separate. We refer to this as 'horizontal separation'. Canonical power system designs emphasize the importance of separation to ensure system operation is free from interference by the regulated economic actors and the political actors that set the rules (Joskow 2008). The argument for separation extends to ensuring that regulatory bodies have sufficient authority to compel changes in the sector. In the US, this separation is pronounced, with the Federal Energy Regulatory Commission (FERC) at the federal level and public utility commissions at the state level

Table 13.1. Four dimensions of governance that affect power system outcomes

Governance dimension	Description
Horizontal separation	To what extent are policy and regulatory functions distinct and separate?
Vertical separation	To what extent are policy and regulatory functions concentrated at the central government level or decentralized to local governments?
Ownership	To what extent is ownership public or private?
Economic planning	To what extent are economic planning and investment planning centralized in government agencies or decentralized to market participants?

Source: Authors' compilation.

responsible for coordinating regulation, and Congress, state legislatures, and executive agencies charged with formulation of policy.

Second, countries and supranational bodies differ in the extent to which policy and regulatory functions of the power sector are concentrated at the central level, or vested with subordinate levels of government, as in a federal system. We refer to this as 'vertical separation'. In many cases, functions are spread across different levels of government, and may come into conflict. For instance, in the US regional wholesale markets are overseen by the FERC, but infrastructure siting decisions and retail electricity prices within those markets are overseen by state regulatory commissions.

Third, countries differ in the extent to which the government directly controls power generation, transmission, and distribution assets through direct ownership or majority or minority controlling stakes. Developing countries, in general, tend to maintain higher government ownership of assets, particularly if direct ownership is deemed central to 'developmental state' priorities (Johnson 1995). Developed countries vary in government ownership of assets. In France, the dominant electricity provider, EDF, is a government majority-owned utility. In the US, most electricity is provided by investor-owned utilities, although the federal government continues to own a significant amount of generation capacity and publicly-owned municipal utilities continue to be important providers.

Fourth, countries differ in their historical and current relationship between the government and the economy more broadly. Some countries still rely on elements of central planning, whereas other countries have a long history of regulated markets. The relative reliance of governments on markets versus planning—either in the present, or historically—is often reflected in governance of the power sector. For example, economies such as China, India, and the former Soviet Union used to be planned economies, and despite adopting capitalist structures, elements of central planning still persist in their power sectors to this day.

13.3.2 Economic Institutions

The second key dimension of this framework is economic institutions, which encompasses the structure of power markets, the relationship between producers and consumers, and the institutions that allocate costs and shape economic behaviour. These institutions vary significantly across electricity sectors, as competition has been introduced to different extents in different parts of the electricity industry in different locations.

13.3.2.1 Industry Structure: Traditional and 'Standard' Restructuring Models

Delivering electricity requires the coordination of five main activities: generation, transmission, system operation, distribution, and retail. In most countries, the first large-scale electricity companies were vertically integrated utilities (VIUs) that owned and controlled all five aspects under a single roof. Governments typically opted for public ownership and operation of VIUs, or created private franchises that obligated utilities to serve all customers at cost-based prices in exchange for a guaranteed rate of return on invested capital, a model known as 'cost-of-service'.

As in other network industries with cost-based tariffs, electricity regulators face significant information asymmetries with respect to which costs the utility should be allowed to pass on to customers. In response to this and a wide array of other factors, in the 1990s a number of countries began to introduce competition in parts of the sector. Based on three decades of reforms, there now exists a 'standard liberalization prescription' that specifies which and in what order certain activities should be made competitive, the appropriate methods for regulating activities that remain monopolistic, and the necessary institutions to ensure well-functioning markets (Joskow 2008: 11–13). In practice, owing to differing motivations for restructuring as well as varieties of institutions, countries have rarely implemented the textbook liberalization approach.

These arrangements differ in their requirements on regulatory institutions. The 'standard' restructured model has the largest diversity and complexity of actors, whereas more vertical arrangements have fewer regulated entities. Across all industry structures, regulators must develop sufficient expertise to evaluate the prudency of investments by network companies. The creation of markets brings additional regulatory complications, as the need for specialized knowledge to validate some costs gives way to the need to recognize and quantify the exercise of market power. In countries with a large public sector and less experience with competition regulation—the case for many developing and former centrally planned economies—this may be even more challenging.

Different generation price formation regimes are typically, but not always, associated with different industry structures. Generation price formation falls into three generic categories:

- Cost-of-service: prudent costs approved by regulator and included in rates.
- Benchmark: price based on the (usually average) cost of a benchmark technology, possibly determined through ‘yardstick’ competition.
- Organized markets: e.g., energy-only market, energy prices determined through bilateral contracts and short-term wholesale market.

Higher penetrations of wind generation generally increase system-wide costs of accommodating wind variability and uncertainty, often referred to as ‘integration’ costs. These costs are compensated to different extents and in different ways under different pricing mechanisms.

Even in regions with competitive wholesale markets, investment in renewable energy is typically driven by incentives that exist outside of the market. The two most common forms of incentive are: (i) feed-in tariffs (FITs) or generation-based tax credits, where renewable generators are paid a fixed price per unit generation (kilowatt-hour) delivered to load-serving entities (LSEs); and (ii) renewable energy quotas, such as renewable portfolio standards (RPS), which require LSEs to procure a certain share of their sales from renewable energy. Hybrids or combinations of these price and quantity mechanisms are common.

13.3.3 Actors and Interests and Wind Energy

The political and economic institutions discussed in Section 13.3.2 engage a set of actors and their interests, which shape power sector decisions related to wind energy. In the end, all actors—which include generators, transmission operators, and distribution companies, dispatch authorities, regulators, and policy makers—play distinct roles in setting the agenda and determining rules that govern the power sector, and are impacted to varying degrees by the system-level outcomes of these decisions.

13.3.3.1 Political Institutions

Depending on their arrangements, political institutions may simultaneously enable and constrain wind: for instance, if policy sets targets for expanding the share of renewable electricity, but also constrains dispatch decisions to time scales not amenable to efficiently integrate wind, conflicts can (and do) emerge. A beneficial political arrangement in one setting may lead to poor wind integration outcomes in another due to reorientation of interests.

First, the horizontal integration of policy and regulatory functions can have clear benefits for wind in countries that have achieved political consensus on the benefits of renewable energies. In this case, regulatory and market institutions may be more easily revisited or altered through administrative measures to reflect how policy incentives play out in the actual operation of the power system and the settlement of its costs. However, if closely entwined policy and regulatory functions are vulnerable to capture by powerful incumbent interests (including pre-existing fossil generators), the incentives for wind integration will be weaker. Even if interest politics plays a smaller role, more frequent interference with the regulatory system may lead to economically suboptimal outcomes and harm long-term development potential of the sector.

Second, vertical integration (centralization) of decision-making authority can ensure that new capacity is optimally located to reflect resource quality and generation needs, whereas greater autonomy for decision makers at subordinate levels could (though not necessarily) lead to suboptimal allocations based on local political conditions. Likewise, increasing geographic scope of transmission and system operation decisions can be favourable to wind integration. By contrast, in the US, transmission siting authority is vested at the state level, even within larger multi-state balancing authorities (MIT 2011).

Third, a high degree of state ownership in the power system can enable or constrain wind generation, hinging on the extent to which state-owned enterprises (SOEs) act as agents subordinate to the state, or conversely, the extent to which SOEs effectively capture regulatory and policy functions. If policy priorities at the top shift in favour of wind, state-owned wind developers are direct beneficiaries.

Characteristics of a nation affect the ability of its economy to generate or adapt to new technologies and practices (Porter and Stern 2001). Instead of claiming that one institutional form is universally superior for wind energy integration and therefore should be grafted onto another with an expectation of similar performance impact, we submit that the more important task involves understanding how institutions shape outcomes and how potential interventions interact with legacy structures in ways that create momentum towards desirable outcomes. For example, as will be discussed later in this chapter, there are aspects of how legacies of planned economic systems result in rigid quota setting (on generation within and trade across provinces in China, for example) that are not compatible with the short-term flexibility required to efficiently integrate wind power.

13.3.3.2 Economic Institutions

Traditional VIUs and restructured markets create different incentives for wind energy expansion. For VIUs, the profit objective for deploying wind will include network expansion and operation costs, and coordinated network and generation expansion has the potential to reduce overall social costs (GE Energy 2010). However, VIUs may not have sufficient incentives to control costs, leading to inefficient investments.

First, how to achieve coordination across functions in support of wind can be a major challenge, depending on market structure. For competitive generation markets, not only are network and generation expansion separated, so are many other economic activities essential to integrate wind, such as price formation at different timescales and ancillary services. Wind may have reduced revenue streams because of an inability to participate in forward energy and balancing markets, and because many markets were not designed to accommodate particularities of wind, there may not be a sufficient variety of market products to incentivize integration.

Second, who determines the terms of access of wind generators to the network? VIUs, which integrate transmission and generation functions, should have an incentive to connect wind quickly. However, in restructured markets, connection is a critical step in wind farm development, and associated costs (including network enhancements) are particularly contentious. Calculating appropriate costs and the degree of socialization will depend on whose calculation it is, whether an ISO, a transmission company, or an integrated network utility. Connection delays can also result in disproportionate hardship on farm owners as a result of cash flow issues, as almost all costs are concentrated in upfront capital.

Third, once connected, wind integration depends on dispatch rules of the system operator. ISOs and VIUs alike will generally try to minimize short-run operational costs, benefitting wind with near-zero marginal cost. Owners of transmission networks that also do system operation may have incentives to dispatch generators connected to transmission lines with favourable tariffs. These incentives in operation also depend on policy and regulations for curtailment, including circumstances in which it is allowed and compensation, if any.

13.4 CHINA CASE STUDY

We apply this framework of interactions of political and economic institutions to help shed light on wind integration outcomes in China, the world's largest energy consumer. China has the world's highest installed capacity of wind energy, but also faces the most severe wind integration situation: curtailment rates—forced spillage of available wind electricity by the grid operator typically for economic or grid stability reasons—have been in the double-digits for at least five years, reaching 40 per cent in some regions during 2015 (NEA 2016). Delay in grid connection to wind farms is another important barrier to smooth expansion of wind energy, with wind installations lacking appropriate connection surpassing 16 GW in 2015 (GWEC 2016). By applying our framework, we can begin to gain a qualitative sense of whether, and how, political economy challenges explain wind development and integration outcomes—or conversely, whether technocratic fixes in the form of capacity targets, price support, transmission build-out, and wind dispatch requirements will be sufficient or sufficiently accepted by the affected parties—to catalyse a low-carbon electricity transition in China.

Many of China's market-based electricity sector liberalization efforts during the early 2000s have been abandoned or significantly altered from their ideal prescription owing to historical legacies and institutional priorities, neither of which are independent. These echo challenges in other country and regional settings, and hence provide a valuable case of the varied political economy impacts of wind energy transitions across the developing world. Figure 13.1 shows the actors in China that participate in decisions related to electricity system functions (capacity planning, generation price formation, dispatch and balancing area coordination, and renewable energy promotion policies) most relevant for the development and grid integration of wind, as a function of industry structures (national, local).

13.4.1 Planning and Project Approval of Wind Farms

Planning—deciding on future generation capacity and transmission needs—and project approval are critical determinants of wind development and grid integration outcomes. Systems vary in the degree to which planning functions are carried out by technical or political bodies. Project approval, also generally by a government or affiliated office, is required before initiating construction of new capacity and transmission projects.

China is perhaps most distinct in the extent of its government involvement in the planning and project approval processes as well as in industry decision-making through state control of firms engaged in all stages of wind farm construction and operation. This reflects, in part, the institutional legacy of China's planned economy, which has persisted longer in electric power than in many other sectors. In practice, it means that generation capacity and transmission planning is largely driven by the supply side, in a top-down manner, targeting a specific installed base without explicit incentives to optimize around system operation.

Planning for wind capacity expansion largely occurs at the central level but siting and integration have been complicated by conflicts with local institutions. The NDRC (National Development and Reform Commission) (together with the NEA (National Energy Administration), after it was created in 2008) sets the national wind capacity target through medium- and long-term industry development plans (Ling and Cai 2012). The national target is then allocated to provinces. Provinces can also volunteer to host large wind bases, as happened in Gansu in 2006–7, and which later obtained NDRC approval, benefitting from central support for long-distance transmission (Davidson et al. 2017). Provincial as well as national officials have incentives to target capacity expansion as it adds to investment, boosting gross domestic product. Capacity expansion also creates local jobs and demand for the output of one of China's strategic renewable energy industries, which was just emerging in the late 1990s and early 2000s. In China, minimizing cost is only one consideration in planning decisions, which reflect many other factors including local economic goals, industrial policy, technological feasibility, and profit-sharing arrangements among local stakeholders.

Historically, wind projects have included government contract projects and concession projects. Before 2003, government contract projects dominated, in which the government directly awarded project development rights to one consortium. After 2003, the concession model was introduced, in which the NDRC selected favourable resource locations for projects and allowed potential developers to bid through a tender process (Han et al. 2009).

Although the concession system enabled rapid development of wind capacity, several features undermined its effectiveness. First, projects were initially selected on a least-cost basis, prompting bidders to offer unrealistically low prices that later undermined quality (Han et al. 2009). Second, pressure to bid at low cost was exacerbated by targets on the largest generation companies to expand renewables to 5 per cent of their total capacity (not generation) (Liu and Kokko 2010). In 2009, bidding with an electricity price was replaced with region-specific benchmark pricing for wind projects based on resources. By this time, there was already evidence that some capacity was of exceptionally poor quality, with turbines producing far less than rated output, requiring more downtime for maintenance, or even collapsing (Han et al. 2009).

Capacity thresholds that determine the level of government at which authorization could be granted also created conflicts between stakeholder interests and wind integration, leading to a situation in which generation expansion rapidly outpaced transmission buildout and exacerbated curtailment. In the early years of wind development in China, all new wind projects required central approval (Han et al. 2009). Development accelerated significantly when approval authority for wind farms sized <50 MW was granted to provincial authorities; indeed, a large number of wind farms built during this period have a capacity of 49.5 MW, as provincial government approval was often the preferred, often faster option to launch wind farm construction.[1] Many wind farm developers at this time were SOEs with access to low cost financing and were rewarded principally according to capacity constructed.[2] However, at this size, the grid company was even more reluctant to connect capacity, especially capacity in remote areas that required significant additional transmission (Yang et al. 2012).

The conflicts related to the planning and project approval process in China are not entirely unique. In other markets, such as the US, it is easier to build new capacity than to site new transmission. In terms of this mismatch, a high degree of federalism plays a similar role in both the US and China. Crossing state (provincial) lines with new transmission requires additional co-ordination and approvals in both countries; however, in China grid expansion arguably faces less resistance from citizens and groups concerned about aesthetic or environmental impacts. Instead, in China resistance arises because the interests and constraints of grid authorities are fundamentally different from those of wind farm developers and their local government champions.

13.4.2 Generator Cost Recovery

The transition to higher wind penetrations often creates economic conflicts between wind and thermal generators, tied to cost recovery. The extent of these conflicts depends on a number of factors, described in Sections 13.4.2.1–13.4.2.4, that are common to both China and other country contexts.

13.4.2.1 Support Mechanisms and Dispatch

In China, wind energy development is incentivized through FITs. FITs fix the price, but not the quantity, of wind power. If the FIT price is sufficiently high, renewable energy developers may rapidly expand installed wind capacity, reducing operating hours, market prices, and revenues for thermal generators. In countries with economic dispatch, this physical and economic displacement of thermal generation occurs primarily through the dispatch merit order, as wind has very low marginal costs.

In China, dispatch order is determined administratively rather than according to marginal cost, and the operating hour impact of higher wind penetrations on thermal generators is, to some extent, negotiated. In most provinces, operating hours for each generating unit are determined through an annual

[1] Cities also competed by offering favourable arrangements for obtaining land for siting wind farms (Liu and Kokko 2010).

[2] At the end of 2008, 90 per cent of China's wind developers were SOEs (Liu and Kokko 2010).

planning process, and system operators (grid companies) dispatch units to meet targets set through this process.[3] In a small number of provinces, dispatch is based on a preset order, with non-dispatchable renewable energy receiving dispatch priority.[4]

Nationwide, China has had a 'mandatory procurement' (*quan'e shougou*) policy for renewable energy since 2005. Wind curtailment rates, however, have been much higher than those seen in other countries with similar levels of wind penetration (Kahrl and Wang 2014). In April 2015, the NDRC issued new rules requiring local planning departments to prioritize renewable generation in annual plans, as part of a broader reform package (NDRC and NEA 2015).

The ongoing nature of dispatch reforms to promote higher utilization of renewable energy in China reflects a conflict between: (i) renewable energy generators and the political establishment, which are keen to promote renewable energy and reduce renewable energy curtailment, and (ii) thermal, and particularly coal, generators, which are keen to limit reductions in their operating hours.

13.4.2.2 Fixed-Cost Recovery

Lower operating hours have a significant impact on coal generators' ability to recover their fixed costs in China, because of the energy-only benchmark approach to setting their wholesale tariffs. Under this approach, all coal generators receive the same price for each megawatt-hour of output, with the price benchmarked against the levellized cost of a supercritical coal unit. This benchmark tariff requires an estimated number of fully loaded operating hours, which for coal units in China is typically around 5000 hours, to convert fixed costs (in yuan per megawatt-year) to a variable price (yuan per megawatt-hour).[5] As the number of operating hours falls, the wholesale price that generators require to recover their fixed costs increases nonlinearly (Figure 13.2).

13.4.2.3 Operating Cost Recovery

At higher wind penetrations, thermal generators are generally required to change their operating practices. This includes (i) maintaining higher reserve

[3] For more detail on this planning process and how it intersects with system operations, see Kahrl and Wang (2014).

[4] This policy is known as 'energy efficient dispatch' (*jieneng diaodu*). For political economic reasons, energy efficient dispatch has proved difficult to extend to other provinces (see Kahrl et al. 2013).

[5] More specifically, the levellized fixed cost (*LFC*, in yuan per megawatt-hour) is calculated as $LFC = AFC/AOH$, where *AFC* is the annual fixed cost (in yuan per kilowatt-year) and *AOH* is the annual operating hours (in hours per year).

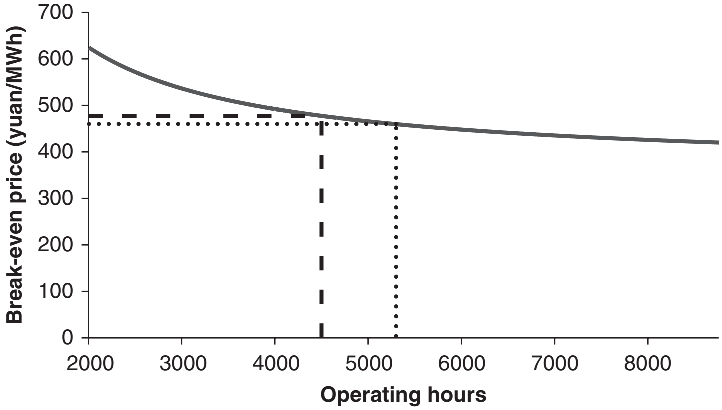

Figure 13.2. Break-even price for a supercritical coal unit in China as a function of operating hours.

Note: This example assumes a capacity cost of 530 yuan/kW-year and an energy cost of 0.36 yuan/kWh.

Source: Authors' calculation based on E3 (2015).

levels, or operating further below rated capacity, to account for the higher uncertainty in wind availability; (ii) more frequent, faster, and deeper changes in output ('ramps') to respond to changes in wind availability; and (iii) more frequent start-ups and shutdowns to respond to the uncertainty and variability in wind output. These kinds of changes in operating practices increase operating costs for coal and other dispatchable generators. Collectively, these additional costs tend to be very small as a portion of system costs, but more palpable as a share of generator profits. In many countries, they are recovered either on a regulated cost basis or through energy and ancillary services markets. In China, however, thermal generators are still not directly compensated for a significant portion of their additional cost of accommodating wind generation.

13.4.2.4 Cost Premium Recovery

China's 2005 Renewable Energy Law created a national surcharge to pay for the higher cost of renewable energy. This surcharge, initially set at 0.001 yuan/kWh, is collected in each province through a 'renewable price surcharge' (*kezaisheng nengyuan fujia*). Grid companies collect these funds separately and use them to pay premiums to renewable energy generators within their own province. Where revenue collection exceeds payment obligations, the funds are collected centrally and redistributed to provinces where payment obligations exceed revenues.

The drawback to this approach is that, if renewable generation grows faster than total demand and/or if coal prices fall, the pool of revenues to pay premiums to renewable generators will be insufficient. In response to rapid growth in renewable energy, government agencies have increased the surcharge twice, to 0.008 yuan/kWh in 2011 and to 0.015 yuan/kWh in 2013. However, the lag between surcharge increases has led to significant gaps—10.7 billion yuan by the end of 2011 (Yu and Xiao 2014)—between what renewable generators are owed under the FIT, and what they are actually paid. Increasing the renewable energy surcharge is politically difficult because: (i) increasing the surcharge raises electricity prices that are already perceived to be high, and (ii) the surcharge is collected nationally and involves significant transfers among provinces.

13.4.3 Balancing Area Coordination

A properly functioning electricity system needs to instantaneously balance supply and demand within a small tolerance. Meeting uncertainties in demand and supply while respecting various system security constraints traditionally requires centralized system operation of dispatching plants (i.e., specifying production quantity). The geographic purview of a system operator is known as a 'balancing area'.

Coordinating neighbouring balancing areas has important benefits for integrating high penetrations of wind and solar energy: aggregating geographically distant resources tends to reduce resource variability; aggregating conventional energy sources increases total system flexibility; and access to more balancing options reduces integration costs such as reserves (GE Energy 2010). As a result of the grid operation institutions in China—including significant vertical separation of operations and planning, and complex horizontal overlapping authorities—the benefits of the large transmission network are not fully realized for wind integration.

13.4.3.1 Structure of China's Grid Operations

Electricity in China, following 2002 reforms, is served primarily by two large central state-owned grid companies, State Grid Corporation of China and China Southern Power Grid Company, and one local grid company, the Inner Mongolia Grid Company. State Grid is further organized into five grid regions, each consisting of roughly five provinces. Within State Grid and Southern Power Grid, direct subsidiary relationships of provincial grid companies within regional grids create nominal lines of authority.

Electric power operations in China involve a range of vertical and horizontal linkages among grid and government institutions. Power plants are for the most part dispatched by the provincial grid company enhancing vertical separation, although there is large heterogeneity across regions. Larger facilities and those serving grid-balancing functions may be directly dispatched by the regional or national grids. Quota-setting and heuristic dispatch ordering take place mostly at the provincial level. Regional grids help coordinate inter-provincial connections whereas the national grid helps coordinate inter-regional connections. These two coordination processes are key to the functioning of the system, and increasingly important for integrating large quantities of variable wind energy.[6] Central policies aim to increase inter-regional exchanges of electricity to exploit remote resources of wind, solar, coal, and hydropower (NEA 2014).

The annual generation planning process ensures that provinces can meet demand with supply and that generators will receive sufficient quotas to maintain profitability. Wind and other renewable energy may be incorporated at this stage by removing a portion of its expected generation from the total available quota. Transmission contracts for exchanges between balancing areas are negotiated in tandem with this process. The institutions involved in annual generation planning and their respective goals are varied (see Table 13.2).

After the heavily negotiated annual plans are finalized, the grid company's goal is to ensure these targets are met by allocating to shorter time periods and adjusting for intra-annual changes in supply or demand. They may be censured by government regulators if they deviate too much (SERC 2011). At the same time, they are faced with the possibly conflicting policy for mandatory procurement of wind. Short-term balancing operations *within* balancing areas are thus heavily constrained. Short-term adjustments *between* balancing areas are even more difficult because quotas are not easily convertible between regions, and the rigid transmission contracting process is difficult to renegotiate (Davidson et al. 2017).

These inflexibilities have led to increasingly high rates of wind curtailment across all major wind regions of China. In the northeast, where a large fraction of coal generators are must-run combined heat and power, Jilin and neighbouring Liaoning experienced 32 per cent and 10 per cent curtailment, respectively, in 2015 (NEA 2016). In the northwest, where a significant fraction of coal plants are directly dispatched by the regional operatorwind curtailment in Gansu reached the country's largest of 39 per cent in 2015 (NEA 2016). In this case, without reforming generation planning—addressing horizontal overlapping authorities—vertical integration has had limited benefits.

Within this rigid planning framework, policy makers in China have piloted various mechanisms—both market and administrative—to increase renewable energy dispatch, primarily focusing on the provincial grid. Energy-efficient dispatch, established in 2009, reorients renewable energy and high-efficiency coal to the top of annual plans, but does not compare plants in different

[6] For a more detailed treatment of institutional coordination issues, see Kahrl and Wang (2014).

Table 13.2. Actors and interests in annual generation planning in China

Actors	Interests
Grid companies	Increase efficiency of delivery (i.e., reduce losses) Utilize transmission lines with energy-based compensation (typically, ultra-high voltage)
Coal-fired power companies	Lobby for higher quotas
Wind companies	Lobby to reduce planned quantities of conventional generation
Provincial governments	Lower local electricity price Promote local generation over imports
National government	Minimize frictions among provinces Conserve resources nationally for energy security and environmental goals

Source: Authors' compilation.

provinces and does not completely do away with the basic quota system to ensure profitability (Davidson et al. 2017). Reforms announced in early 2015 highlight reducing the total amount in the plan (hence available for quota) as well as prioritizing renewable energy in cross-region transfers (NDRC and NEA 2015).

Vertical integration through regional power exchanges has been piloted and disbanded multiple times as many institutions sought to stall reform. According to one account, provincial governments and generation companies were united in opposition: provincial governments did not want to give up autonomy over planning decisions through a regional market, and risk-averse generation companies had already grown accustomed to the guaranteed revenue streams under the quota system (Wen 2014).

13.5 CONCLUSION

Energy system transitions, by introducing or replacing one technology or practice with another, inevitably create winners and losers. To better assess the landscape of political economy obstacles to energy system transition, in this chapter we developed an analytical framework to understand the political economy of wind energy—a high potential source of zero-carbon dioxide electricity.

At the generator level, the political economy impacts of wind power are in part driven by wind's physical characteristics. Wind displaces conventional dispatchable resources (e.g., coal, natural gas generation) because of its low marginal costs, but requires dispatchable resources for balancing because of its limited predictability and variability. This may reduce capacity utilization of conventional dispatchable generators and force them to operate in new conditions, creating costs that may or may not be remunerated under existing market or regulatory rules.

Yet, as we showed, the political economy impacts of wind extend beyond transfers among generators. Greater investment certainty for wind generators is underwritten by electricity customers, and governments may transfer more of that risk onto specific classes of customers (e.g., residential or industrial customers). Regional dispatch can reduce the operating challenges of wind power, but integrating local electricity systems into more regionally coordinated dispatch creates economic transfers between higher- and lower-cost regions. The losers in these political economy conflicts will often resist policies that support wind, renewable energy, and energy transition.

By applying our framework to China, a country with electricity sector institutions that are very different from those in most other countries, we demonstrated how wind development and integration challenges in China can also be understood within a more general political economy framework. On the basis of our analysis, we surmise that vertical separation (i.e., degree of federalism) plays a very important role in explaining wind integration outcomes in China, perhaps as important as in the US and Europe. We also find evidence that underneath the veneer of stronger horizontal integration in China the disparate interests of actors can lead to poor coordination across functions such as generation and transmission planning, or generation planning and dispatch, with consequences for wind development. Fleshing out on-the-ground implications of vertical and horizontal separation for wind integration is an important topic for future empirical work.

China is, in many ways, an extreme case because of the severity of its wind energy curtailment problem. As such, China presents a cautionary tale of the perils of not proactively identifying and addressing potential political economy conflicts. We argue that, although the technical challenges of renewable integration may have reasonably straightforward solutions, addressing political economy challenges by their nature must be built into longer-term political and economic strategy. In developing policies to facilitate low-carbon energy transitions, governments should ensure that they simultaneously acknowledge and address potential political economy conflicts.

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