Energy Policy 127 (2019) 200–212

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

The China wind paradox: The role of state-owned enterprises in wind power investment versus wind curtailment

Mengye Zhu[a], Ye Qi[a,b,*], David Belis[c], Jiaqi Lu[b], Bart Kerremans[c]

[a] School of Public Policy and Management, Tsinghua University, Haidian District, Beijing 100084, China
[b] Brookings-Tsinghua Center for Public Policy, Tsinghua University, Haidian District, Beijing 100084, China
[c] Leuven International and European Studies (LINES), Faculty of Social Sciences, University of Leuven, Parkstraat 45, 3000 Leuven, Belgium

ARTICLE INFO

Keywords:
Wind power
China
State-owned enterprises
Investment
Political economy

ABSTRACT

China has seen a surge in wind power installation over the past decade, and is now the world leader in installed capacity. However, wind curtailment – i.e., when the power grid frequently interrupts the power connection of installed wind capacity – has become an increasingly serious problem. But despite wind curtailment significantly jeopardizing wind power developers' profitability in China, companies have continued to invest. This study, based on extensive interviews with decision-makers in China's Central State-Owned Enterprises (CSOEs), attempts to explain this seeming paradox. Since the majority of wind power investment in China has been made by CSOEs, previous findings of SOE studies assume that this continued investment abjures "economic rationality" due to political/policy burdens. However, this study shows that this is not necessarily accurate. CSOEs' investment behavior also accords with market logic, as they competed fiercely over wind power sites, increasing investment scale as a rational long-term strategy of profitability. We also find that the embrace of market logic by CSOEs has resulted from recent economic and power sector reforms. For a more efficient market, policymakers must pay greater attention to the quality of competition among CSOEs.

1. Introduction

1.1. Wind curtailment issue in China

Over the past decade, China has experienced a surge of investment in wind energy. In 2016, installed wind capacity reached 149,000 MW (NEA, 2017b), 438-times higher than in 2000 (Chinese Electric Power Yearbook Committee, 2001). Additionally, China became the world's leading investor in wind energy in 2010 (Wang et al., 2012). Since 2010, however, this rapidly growing industry has faced a rising challenge from wind curtailment : i.e. the abandonment of power generation of grid-connected wind power capacity (Dong et al., 2018). The power grid operator, mainly the State Grid Corporation of China, has decided to interrupt or intermit the grid connection of installed wind capacity during power dispatches.

Wind curtailment in China has resulted in sharp declines of utilization hours of wind power equipment, creating a growing divergence between installed capacity and actual power generation (Fig. 1). Energy loss from wind curtailment has been significant, and is worsening. China' average wind curtailment rate in 2011 was 16%, resulting in a loss of 12.3 million MWh of electrical power (Zhang, 2016).[1] The numbers rose to 19% and 49.7 million MWh in 2016 (NEA, 2017b), equivalent to nearly 75% of total solar power generation in China that year. Wind curtailment occurred primarily in the northeastern, northern and northwestern China, also known as the Sanbei region which translates to the "Three North Regions" (Luo et al., 2016).

Eight provinces suffered from wind curtailment in this region: Liaoning, Jilin, Heilongjiang, Hebei, Inner Mongolia, Xinjiang, Ningxia, and Gansu. More than 60% of wind power is located in this region due its quality and abundance of wind resources (Fig. 2). The under-utilization of wind power may jeopardize China's ability to meet its renewable energy goals, as officially announced in the country's Intended Nationally Determined Contributions (INDC) to the 2015 Paris Agreement.

In recent years, the causes of China's severe wind curtailment have been extensively debated. Technical and socio-economic reasons have

* Corresponding author at: School of Public Policy and Management, Tsinghua University, Haidian District, Beijing, 100084, China.
E-mail address: qi@tisnghua.edu.cn (Y. Qi).

[1] Dong et al. (2018): Wind curtailment rate (Cr) is officially defined as the share of wind power generation being curtailed (CWind) against the theoretical wind power generation (TWind). The difference between CTWind and CWind is actual wind power generation RWind. Therefore, the wind curtailment rate is calculated as: $Cr = \frac{CWind}{TWind} = 1 - \frac{RWind}{TWind}$.

https://doi.org/10.1016/j.enpol.2018.10.059
Received 27 January 2018; Received in revised form 25 October 2018; Accepted 28 October 2018

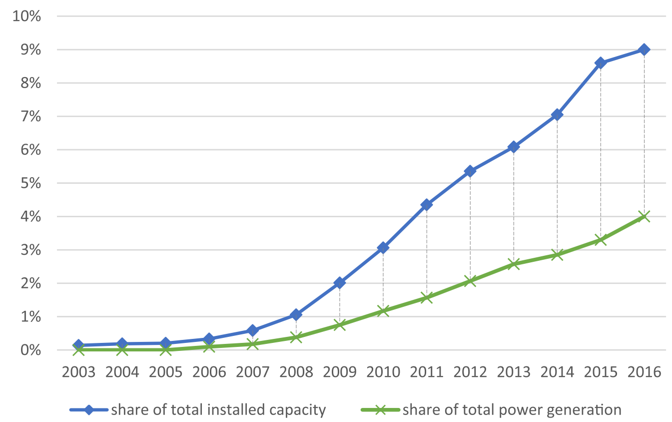

Fig. 1. Wind power's share of total installed capacity and power generation in China.
Sources: National Bureau of Statistics of China (2016) Chinese Electric Power Yearbook Committee (2007-2015) NEA (2016), NEA (2017b)

been flagged by researchers as being the most important, including grid inflexibility and insufficient transmission capacity (Davidson et al., 2016; Luo et al., 2016; Shu et al., 2017; Xiong et al., 2016), power planning and administrative barriers (Lu et al., 2016; Luo et al., 2012; Pei et al., 2015; Zhang et al., 2016b), and the mismatch between power supply and demand (Qi et al., 2018; Yang et al., 2012), especially under the economic "new normal" of slower growth and a structural transition away from heavy industry (Dong et al., 2018).

1.2. The paradox of wind power companies under wind curtailment

Wind curtailment can significantly undermine power companies' profitability (Lewis, 2016; Luo et al., 2016). Nevertheless, there has been a paradoxical behavior of wind power companies. Despite increasing wind curtailment, wind power investments have continued to surge in China, especially in the Sanbei region (Fig. 3). To put it simply, investment decision-making seems to have been decoupled from economic rationality.

The profit of a wind farm is the difference of income of power generation and the total cost, expressed as:[2]

$$I = E \times P + S^* \quad (1)$$

$$E = C_{op} \times CF \times (1 - Cr) \times 8760 \quad (2)$$

$$TC = U \times C_{op} + C^* \quad (3)$$

In Eq. (1), I is the income; E stands for the annual wind power electricity; P refers to the benchmark price subsidized by the Fit-in-Tariffs (FITs), S^* is other subsidies from the government or the Clean Development Mechanism (CDM).[3,4] In Eq. (2), C_{op} refers to grid-connected wind capacity. CF stands for the capacity factor that wind farms can achieve without wind curtailment. Cr is the percentage of wind power that is curtailed; 8760 is the total number of hours in a year (Lu et al., 2016). And in Eq. (3), U refers to the unit capacity cost of wind turbine and C^* is other costs including loan interests and other fees.

Wind curtailment negatively affects the capacity factor, or the utilization hours of wind farms, decreasing the amount of wind-generated electricity.[5] From 2011–2016, the total loss of wind power generation was 145,500,000 MWh (NEA, 2017b; Zhang, 2016), resulting in approximately 12.5 billion USD worth of losses for wind developers (Zhang et al., 2016a).[6]

Meanwhile, the supporting policies of wind power were increasingly less effective. In 2005, the Renewable Energy Law was enacted to offer wind power developers tax reduction and subsidies (Wang et al., 2010). There was a subsidy of 300 RMB per kilowatt from 2006 to 2011 (Luo et al., 2016). And the National Energy Administration (NEA) has subsidized wind power projects as the benchmark price since 2009 (NDRC, 2009). Local governments would attract wind power developers with low-cost land use and other favorable conditions. However, wind power developers gradually faced challenges of diminishing subsidies. The National Development and Reform Commission (NDRC) lowered the wind power on-grid benchmark prices three times (NDRC, 2014b, 2015, 2016). And the national renewable energy subsidies failed to be appropriated on time (BJXnet, 2015). Instead of offering subsidies, some local governments even asked the developers for wind resource taxes, which increased the costs of developing wind farms (China Economy Net, 2013). The cost reductions from technological progress and wind turbine manufacturing have been offset by wind curtailment rates exceeding 10%, along with a drop in funding from CDM for wind farms (Luo et al., 2016). Furthermore, the subsidies fell short when they encountered severe wind curtailment. Thus, companies in the Sanbei region experienced significant revenue loss or even became unprofitable.

The concerns of wind farm profitability began to show up as early as 2009 (Netease, 2009). A comprehensive investigation conducted by the State Electricity Regulatory Commission in 2009 revealed that some wind farms in the Sanbei region were suffering from economic difficulties or profit loss due to curtailment (Ifeng News, 2009). In 2011, a report from China Electricity Council, a central government-based power industry association, showed that the five largest power CSOEs experienced a total loss of 140 million RMB in wind power business in July and August of that year (Ifeng News, 2011). In 2014, it was also reported that more than 50% of China's wind power investment was facing revenue loss since the third quarter of that year, according to an executive-level officer from one of the largest power enterprises in China (Sina, 2014).

Given the many difficulties in accessing the financial records of wind power projects and the confidentiality of related data, we conducted extensive interviews with insiders from the industry about profitability conditions. It was widely admitted that revenue loss of wind farms was very common in the Sanbei region and wind curtailment was the biggest threat to profitability [I02; I05; I06; I08; I09].[7] For instance, the average economic break-even point of wind farms in Guazhou county of Gansu was approximately 1800 h of utilization. The actual utilization hours, however, decreased from 1859 h in 2013 to 992 h in 2016 [G01], indicating significant revenue loss. And a common industrial estimation was that wind curtailment rate higher than 20% would definitely lead to profit loss [I05; I08].[8]

This paradox has prompted much media attention (BJXnet, 2014b, 2017; Sohu, 2017) but little academic research. This paper aims to address this paradox by answering the research question: why did wind power companies in China keep investing despite increasing wind curtailment? Since little public data exists for the question, we fill the gap between inaccessible data and available data with expert elicitation by conducting extensive interviews with 50 stakeholders.

In Section 2, we first present the research background about CSOEs and their role in China's energy economy. Section 3 details the methodology of our exploratory qualitative research, specifically about how and when the interviews were carried out, and the supporting documentary analysis. Section 4 presents the research findings, grouped into two primary results. Firstly, this study found that there was no direct mandate from the central

2 See Methods from Lu et al. (2016).
3 The benchmark prices of wind power are determined by NDRC based on the quality of wind resources. Wind resources in China are divided into four classes (I-IV) representing high to low quality with corresponding benchmark prices from low to high.
4 CDM is a mechanism from Kyoto Protocol (IPCC, 2007) that provides for emissions reduction projects to trade emissions reduction units in the emissions trading schemes.
5 The utilization hours are calculated as CF*(1-Cr)*8760.
6 Using an electricity price of USD 8.6¢/kWh for Chinese wind power.
7 See Appendix A for interview codes.
8 See Appendix B for document codes.

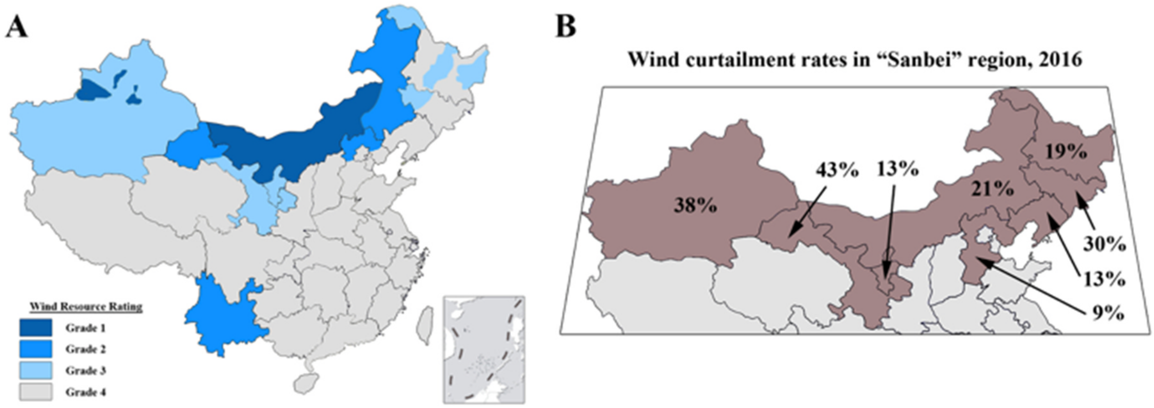

Fig. 2. Wind energy resources and curtailment rates in the Sanbei region.
Sources: NDRC (2016); NEA (2017b)

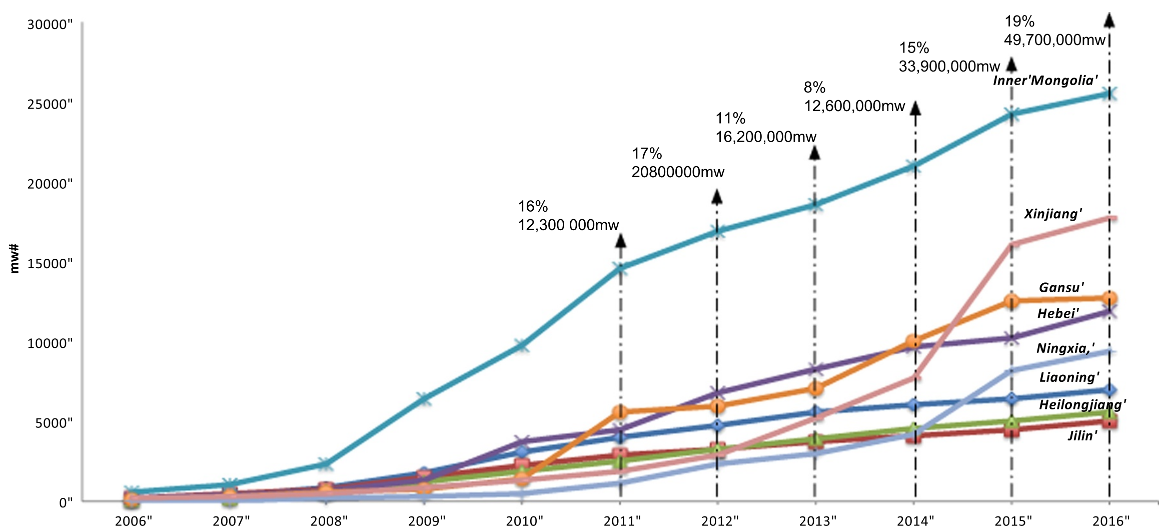

Fig. 3. Wind power installation and wind curtailment in the provinces of the Sanbei region. Numbers next to the arrows refer to the average wind curtailment rate and total curtailed volume of that year in China.
Sources: Chinese Electric Power Yearbook Committee (2007-2015); Zhang (2016), NEA (2016); NEA (2017b).

government and CSOEs enjoyed decision-making autonomy regarding wind power investment. Secondly, CSOEs continuing to invest despite wind curtailment was a rational strategy for long-term profitability. Section 5 discusses the potential significance of the research findings, and situates them in the existing literature and the relevant policy environment in China. Finally, Section 6 offers concluding remarks.

2. The roles of state-owned enterprises in China's wind power development

Answering the research question posed in this study requires focusing on China's state-owned enterprises – namely central government-run state-owned enterprises (CSOEs). Pillars of China's so-called "state capitalist" economy, they have also played an indispensable role in the country's wind power development. In 2013, more than 80% of China's installed wind capacity was operated by SOEs (Luo et al., 2016). The nine largest power companies in China are the "Big Five" and "Small Four" enterprises, as they are popularly known; all of them are CSOEs.[9] And eight of them ranked in China's top 10 wind power developers in 2013, accounting for 71% of the market share (Fig. 4). The "Big Five" alone accounted for 55% of total capacity in 2013 (Luo et al., 2016). Therefore, the investment decisions of these CSOEs are key to understanding the paradox of wind power investment in China.

2.1. The government-related procedures for wind power investment

In principle, wind power projects follow NDRC-mandated guidelines (NDRC, 2003) and conduct project feasibility assessments, requiring a project to calculate its Net Present Value (NPV) in order to assess its economic feasibility. NPV is the traditional, and by far the most widely used, financial method to calculate investment profitability (Ross, 1995). The general form of a NPV calculation is:

$$\text{NPV}= \quad V - I_0 = \sum_{t=1}^{n} \frac{C_i - C_0}{(1+r)^t} - I_0. \tag{4}$$

Here, V is a given project's expected return, I_0 the amount of initial investment, C_i the average annual project cash-in, C_o the average annual project cash-out, r the discount rate, and t is the timeframe of the project.

[9] The"Big Five": China Huaneng Group, China Datang Corporation, China Huadian Corporation, China Guodian Corporation, State Power Investment Corporation. The "Small Four": China Resources, State Development and Investment Corporation, China General Nuclear Power Corporation (CGN), Guohua Electric Power Company.

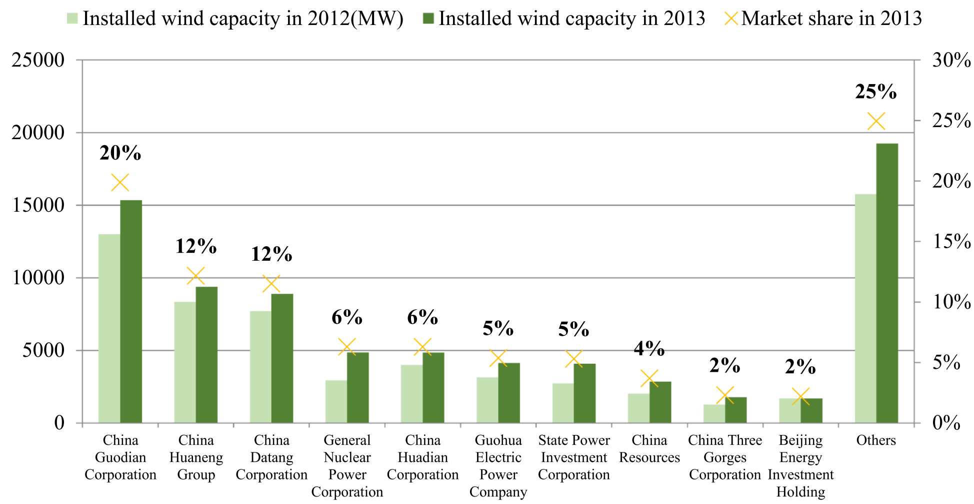

Fig. 4. The top 10 wind energy enterprises in China in 2012 and 2013, as measured in installed capacity and market share.
Sources: BJXnet (2014a)

Table 1
Administrative approval jurisdictions of wind power projects.
Source: Luo et al. (2016)

Year	NEA	Local authorities
2004–2010	Approved wind power projects of installed capacity of 50 MW and above	Approved projects under the installed capacity of 50 MW
2011–2013	Took back the approval jurisdiction from the local government. Approved all wind power projects.	No approval rights
2013-Now	Delegated the approval jurisdiction to local authorities	Approved all wind power projects with a few exceptions

Central to the concept of NPV is the internal rate of return (IRR), which is the discount rate when NPV equals zero (i.e., IRR = r, when NPV = 0). IRR represents the bottom line of profitability of a project, meaning the minimum rate of return a project can have in order to cover the costs of a wind project's life cycle (which on average lasts approximately 20 years in China). Therefore, the higher the IRR, the higher the expected profitability of a project. CSOEs made decisions about whether a potential site was worth investing in based on IRR calculations, and set minimum IRR thresholds, normally from 8% to 10% [I06; I08; I18; I33; I34]. Projects that passed the requirements received investment.

Wind power projects must be approved by the government. The administrative authority for wind power development is located in the NEA, which guides and monitors wind power development. Specifically, it sets Five-Year-Plans (FYPs) for general installation targets and makes supporting policies. NEA has devolved its power of approval to the local authorities (Table 1):

The delegation of NEA's approval power made the projects easier to get approved, accelerating wind power investment, as local governments welcomed investment for local economic growth. However, NEA still held the rights to veto projects if needed. For instance, the development goals for other provinces with significant wind curtailment were restrained yet negotiable because NEA had to prevent over-investment (NEA, 2013). NEA also issued red alerts for wind power investment in six provinces with severe wind curtailment in 2017, banning new projects approval and installations temporarily (NEA, 2017a).

2.2. Literature review of the traditional SOEs studies

Since the absolute majority of wind power investments were made by SOEs, a widely assumed explanation to the paradox of continued investment under severe wind curtailment was that the central government has made the growth of renewable energy a high-priority national goal, formalized since 2005 in the Renewable Energy Law. Being government-owned entities, CSOEs are therefore obliged to further this national prerogative at any cost. Thus, it is only political rational for CSOEs to deviate from economic rationality based on the widespread view in traditional SOEs studies that the government, being the largest shareholder, controls business operations (Du and Wang, 2013; Huchet, 2003; Johns, 1995; Koppell, 2007; Zhang, 2015).

Therefore, the prevailing findings in much of the field is that different from private companies, which accord with the market logic of profit-maximization, China's SOEs follow political logic, even when it is opposed to economic rationality (Wang, 2008). Studies show that state ownership inevitably exposes enterprises more to political interventions than private ownership does (Fan et al., 2007; Morsing, 2011; Roper and Schoenberger-Orgad, 2011; Zif, 1981). Thus, they are obligated to bear policy burdens, i.e. responsibilities to fulfill the government's non-profit-seeking goals, including “social burdens” and “strategic burdens” (Lin, 1999; Lin et al., 1998; Lin and Tan, 1999; Liu et al., 2016). For example, some Chinese SOEs have to maintain overstaffed employment for social stability reasons (Dong and Putterman, 2003; Du and Wang, 2013). SOEs are also considered as the pioneer of the development of new technologies or strategic industries, which are key to long-term, national development goals (Clò et al., 2015; Du and Wang, 2013; Naughton, 2017). When the economic and non-economic objectives are in conflict, it is believed the former is usually subordinated to the later. Therefore, SOEs usually serve as policy instruments to fulfill these non-profit-seeking goals of the government (Dai, 2013; Schroeter et al., 2016; Zhao-Yang, 2014). As a consequence, SOEs’ autonomy or control rights in economic activities and business decision-making, including strategic business-boundary issues, pricing decisions, resource acquisition, and mobilization issues are severely compromised (Groves et al., 1994; Lioukas et al., 1993; Naughton, 2017).

Due to policy burdens, it is difficult for the government to distinguish between policy-induced losses and regular business losses of SOEs (Liao et al., 2009). Therefore, SOEs would obtain privileged support from the government in return to compensate their economic losses (Milhaupt and Zheng, 2015), known as the “soft budget constraints”

(Kornai, 1986; Lin and Tan, 1999; Qian and Roland, 1996). As a result, SOEs in general do not bear the cost or enjoy the benefit of investment in the way that private firms do, as they could enjoy “soft budget constraints” from the government (Chow et al., 2010). Moreover, SOEs are often operating in monopoly industries in which the market is uncompetitive (Xu, 2010; Yuan and Shao, 2010). In such conditions, there are often arbitrary investment decision-making (Dan, 2009; Liu and Wang, 2004), especially in the absence of market competition (Lin et al., 1998). Therefore, SOEs are often accused of being insensitive about revenue loss and inefficient in terms of profits, productivity, and growth compared to private firms (Li et al., 2014; Sun et al., 2005).

To sum up, the theory outlined by traditional studies would assume that increasing wind power capacities is a political mandate from the central government. CSOEs have to continue investing even if they suffer profit loss; and they are arbitrary and less motivated to be cost-efficient in business decision-making than private firms are due to state ownership, soft budget constraints, and insufficient market competition. In other words, CSOEs do not follow market logic in wind power investment.

To test the above hypothesis requires detailed empirical studies. Gathering empirical information, especially first-hand, from CSOEs has historically been difficult, as political sensitivities and corporate considerations greatly limit access. Therefore, SOEs studies are in need of qualitative studies for exploratory purposes (Daiser et al., 2017). There are even fewer studies revealing the decision-making processes of CSOEs in China. To fill this gap, we conducted extensive interviews in with CSOE executives, middle managers, and other employees to answer the question: why have wind power CSOEs continued to invest despite wind curtailment, and the economic rationale to do so?

This study finds that the conventional argument outlined above is incomplete to answer the question. In fact, CSOEs also employ economic and market logic in investment decision-making with respect to wind farms. And we argue that this economic rationale has resulted from economic and power sector reforms. The central government, through the reforms, has created a market in which CSOEs engage in significant levels of competition with each other. Yet the market is constrained by administrative hurdles, notably the benchmark prices determined by NDRC and the central state-owned oligopolies dominating electricity supply. We also find that this economic rationality of CSOEs is encouraged by the performance evaluation of the central government (Table 2).

3. Methods and materials

3.1. Exploratory qualitative study

This research is an exploratory qualitative study of the investment decision-making mechanisms and the logic of CSOEs under conditions of wind curtailment. Qualitative methods of this kind are widely applied in studies that are detailed, text-based, and/or historical (Vromen, 2010). Furthermore, answers to research questions usually include personal reflections from participants of the studied event (Brady and Collier, 2010; Vromen, 2010). This type of methodology is well-established and has been used to understand a wide range of topics, including public responses to natural disasters, habitat protection management, and firms' energy conservation behavior (Hawkins and Maurer, 2009; Kalfagianni and Kuik, 2016; Morrison, 2017; Zhao et al., 2014; Zhao and Ortolano, 2010). To answer our research question, we conducted extensive semi-structured interviews with stakeholders who experienced the studied phenomena, as well as through analysis of related documents provided by the interviewees and other relevant sources (Starks and Trinidad, 2007).

3.2. Semi-structured interviews

This study draws upon 38 in-depth confidential interviews with 50

Table 2
A comparison of traditional perceptions on private firms and SOEs and the new evidence from the studied CSOEs.

	Economic rationality/profit maximization	Political mandates/ policy burdens	Investment decision-making	Market competition	Market logic
Private firms	Yes	Very few	Cautious, cost-effective	Strong	Yes
Traditional studies on SOEs	No	Many	Arbitrary, cost-ineffective	Weak	No
Evidence from the studied CSOEs	Yes, but created by the central government	Fewer. No direct mandates	Cautious, cost-effective	Strong	Yes, but constrained by administrative hurdles

interviewees (Appendix A). We conducted 19 semi-structured interviews with 26 employees from different CSOEs. 16 of them were key decision-makers or participants, including middle-and high-level managers from headquarters and subsidiaries (e.g., department heads and a vice president) and the rest were directors or day-to-day operators of the wind farms of these CSOEs. Seven CSOEs were investigated in total. Six CSOEs in our study belonged to the top 10 largest wind power investors in China and the other was a pioneer in wind power development in China, being an early entrant into the industry. As the top 10 wind power enterprises accounted for 75% of China's installed wind power capacity in 2013, the selected cases are strongly representative of the general behavioral dynamics of the country's wind power companies. For reasons of personal and professional privacy, we withhold the names of the CSOEs and their employees from our study.

To provide a more comprehensive understanding of the conditions under which investment decisions are made, and as contextualizing reference points, we also interviewed 24 decision-makers or key participants from other related organizations including provincial and local renewable energy bureaus, private wind power companies, large investment banks, the State Grid Corporation of China (SGCC) and the Chinese Wind Energy Association (CWEA), a long-standing non-governmental industrial association established in 1981.

Of the 38 interviews, 32 were face-to-face and four were by phone. Each interview lasted an hour or more. Two interviews were conducted on the basis of structured questionnaires. We also participated in and observed a 3-h closed-door meeting, led by the National Energy Administration (NEA), in Gansu province, addressing the wind curtailment issue with stakeholders including officials from NEA, the Gansu provincial energy bureau, and the energy departments of local governments. Managers of wind power companies and the State Grid Gansu Company also participated in this meeting. Finally, regular follow-up communications with interviewees via telephone calls, emails, and text messages were made after the interviews, to check for further developments and to clarify ambiguities in the interview material.

The interviews were conducted between May 2016 and July 2017. Other communication documentation, such as follow-up text messages, were also retained for the record. The timeframe of the information given by the interviews – and therefore the timeframe of this study – date from 2005, the beginning of China's massive development of wind power, to 2016. The interview questions varied according to the occupations of the interviewees. In general, we asked questions to employees of the CSOEs about: (1) the processes and procedures of investment decision-making and wind power projects; (2) the key determinants of wind power investment decisions; (3) how their companies' wind power business changed over the past decade; (4) their firms' reactions to wind curtailment and the reasons they invested under those circumstances. Other interviews were focused on: (1) the macroeconomic and political settings of the wind power industry and its development in China, including the origins of wind curtailment; (2) concerns of wind curtailment from policymakers' perspective; (3) the general industrial structure of China's wind power operations and the related investment environment. We also asked non-CSOE interviewees about their knowledge about wind curtailment and wind power companies' investment decisions as a robustness check. Most of the interviews concentrated on the Sanbei region with three exceptions being non-Sanbei branch companies of CSOEs in Hubei and Guizhou province. Similarly, follow-up communications helped to improve, or at least check for, the reliability and consistency of the interview answers.

3.3. Documentation and analysis

A documentary review was undertaken of key documents (n = 10) (Appendix B) provided by the interviewees from CSOEs and public material such as news articles, research reports, and government policy papers to understand the evolution of the wind curtailment issue, related government policies, and how this influenced investment decisions of CSOEs. They also provided objective supporting evidence to answer the research question, in addition to the more subjective information provided by the interviews.

4. Research findings[10]

Contrasting from the conclusions of traditional SOE studies in Section 2, the respondents' answers and the analysis of supporting documentation revealed market logic at work in the decision-making of CSOEs in wind power investment, and in a great detail. Firstly, this study found that there was no direct mandate from the central government regarding wind power installations. CSOEs enjoyed decision-making autonomy in wind power projects. And the decision-making process was not arbitrary. Secondly, CSOEs continuing to invest despite wind curtailment was a rational strategy for long-term profitability to cope with fierce competition for scarce wind resources. Thus, economic rationality should not be overlooked in SOE studies.

4.1. The decision-making of CSOEs in wind power investment

4.1.1. CSOEs have autonomy in decision-making

In the case of wind power, CSOEs had relatively high autonomy in wind power investment. They themselves decide investment scales and strategies. CSOEs made their own investment plans at the beginning of each year, including for the specific installed capacity targets of each of their branch companies [I06; I08; I09]. Even though the National Energy Administration (NEA) issued Five-Year-Plans (FYP) for wind power, setting suggested goals for total installations by the end of the five-year period, there were no direct mandates for each CSOE to invest in wind farms. FYPs only served as guidance to broader wind power development [I10; I24; I31; I38]. The annual national and provincial installation goals were not assigned top-down, but followed a bottom-up arrangement. The annual national development plan of wind power was usually an aggregation of all the potential projects or total investment scale reported by the provincial energy administrations [I38]. NEA finalized the annual wind power development plan, which legitimized wind power projects based on the developers' applications from different provinces. There were few limits in provinces that had none or less-severe wind curtailment [I08; I31].

Thus, CSOEs' incentives, like private-owned developers, were endogenous, not exogenously imposed by the central government's mandates in terms of investment scale [I11; I36]. In fact, the investment in wind power always exceeded the planned targets. For example, the expected installed capacity of wind power in the 11th FYP was 10,000 MW by the end of 2010; the actual number exceeded 30,000 MW. And the installed capacity in 2015 also surpassed the target set in the 12th FYP by 30 million MW. They could have stopped investing if they were willing to do so. For instance, one CSOE decided to give up the development right because of aggravated curtailment [I09; I18; I28]. Clearly, CSOEs experienced a relatively high degree of autonomy with regard to investment decisions.

4.1.2. CSOEs' decision-making process was not arbitrary

Studies have argued that SOEs care less about cost and benefit in business decision-making, resulting arbitrary business decisions (Dan, 2009; Liu and Wang, 2004). However, our analysis shows that this is not necessarily true in wind power investment. The decision-making processes for wind power investment of the studied CSOEs were not arbitrary but standardized with multiple evaluation stages. The

[10] The research findings summarize interviews and the collected documents. However, due to the length and format requirements, the authors only cite a number of interviews and documents that can mostly represent the findings.

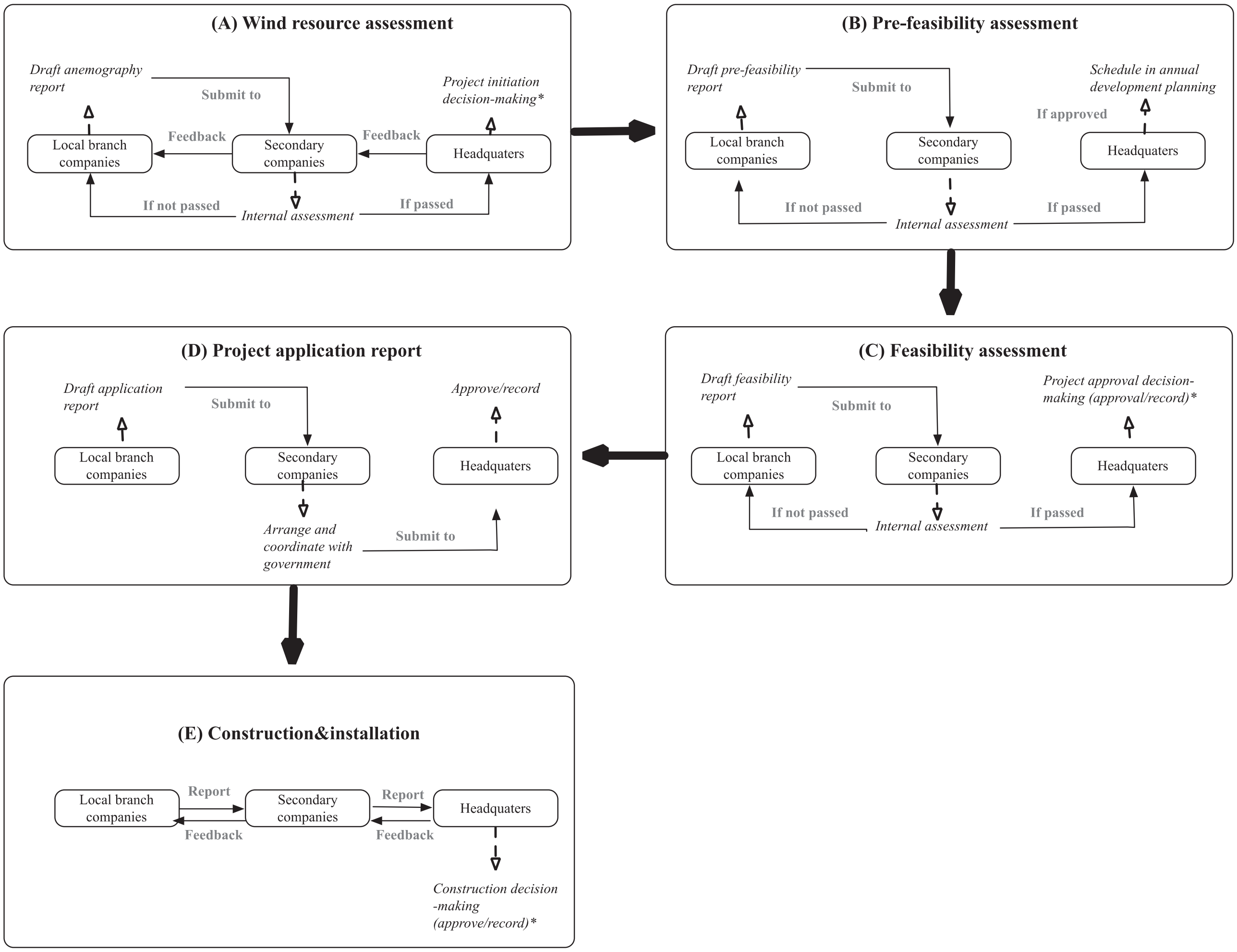

Fig. 5. A flowchart illustrating the corporate governance structure and decision-making process behind investment decisions for wind energy CSOEs.
Source: I06, I08; F01, F02

processes were more sophisticated than the decision-making of the studied private firms [I11; I34; I36]. The processes varied in detail, but also showed important similarities. All of them followed standardized procedures to guarantee accountable investments. Most studied CSOEs had three tiers in its corporate structure: headquarters, secondary companies (regional-branch and specialty-focused businesses), and local branch companies (usually affiliated with a secondary company) [I06; I08; I09; I12; I26; I32; I34]. In general, the decision-making process passed through all three levels from the bottom-up. Potential wind projects were usually discovered by local branch companies or secondary companies.

According to the internal process requirements, project-related materials had to be submitted to the higher-level companies based on CSOEs' decision-making timetables. Usually, there were three decision points: initiation decision, project approval decision, and construction decision [I06; I07; I24; I32]. At these points, local branch companies had to report and submit required paperwork to their affiliated secondary companies. Afterwards, these secondary companies organized evaluation meetings to discuss the project in detail to optimize technical and construction solutions, such as wind turbine selection, grid transmission and transportation [F02]. The results of the evaluations were then given to the local branch companies and also reported to headquarters [I24]. Headquarters then devolved power back down to the secondary companies for investment details (Fig. 5).

The gap between investment decision-making and capacity installation was usually two years [I08]. Thus, the three decision points (Fig. 5: A, C, E) allowed CSOEs to evaluate and re-evaluate a potential project in case of changing investment conditions during the process [I06; I09]. For instance, CSOEs deployed benchmarking schemes to optimize the costs of the potential wind farms.[11] It required that the costs of a wind farm must match those of the best performing peers located in the same area (e.g., same county) and were developing at the same time [I06]. And CSOEs could also improve the requirement of minimum IRR for risk control and slow down the investment if needed [I08]. Projects failing to pass the evaluation process were not unusual in CSOEs [I06; I26].

4.2. Increasing investment scale for long-term profitability

4.2.1. The market logic of increasing investment scale

Foremost among the investment strategies discussed in all the interviews was to increase investment scale as a rational strategy to benefit the CSOE over the long run [I06; I08; I24; I25; I26]. Expectations of long-term financial gain drove investment, assuming that wind power would be an increasingly important feature of China's energy economy going forward [I24; I25]. In the absence of severe wind curtailment, increasing investment scale was an economically rational

[11] "Dui biao" in Chinese.

choice for firms.

First of all, the hearsay of the official establishment Renewable Portfolio Standards (RPS) was the primary reason for CSOEs to expand their wind power business in the first place [I01; I06; I08; I10]. RPS was a quota system that mandated large power companies to generate or purchase renewable power as a set percentage of their total power generation. NEA had been planning to establish the RPS since 2007 (NEA, 2007). Rumors had it that if the companies failed to meet the quota, coal-fired power generation would be limited [I06; I10]. However, it was never officially settled as a government policy. The uncertainty of this policy motivated power CSOEs to develop their own wind farms in order to match production for economic considerations. For one thing, they were afraid of losing coal-fired business, and for another they wanted to avoid the transaction cost of purchasing renewable power from other companies [I06; I07; I08; I09]. Therefore, the larger the companies were, the more wind power generation they needed.

Secondly, wind power projects in the Sanbei region tended to be highly profitable due to high-quality wind resources and low land costs [I08; I18; I34]. The central government provided feed-in-tariff subsidies and many local governments at that time promised wind power developers favorable administrative and financial conditions in order to attract investment [I23; I28]. It was estimated that an average-size wind farm in Gansu would gain 70,000 RMB per day before severe wind curtailment happened, and that the monthly wage of a wind farm staff was over 5000 RMB at that time [I27], considerably higher than the average income in Gansu.

Thirdly, though the break-even point of wind projects varied across cases, approximation of the wind curtailment threshold for industry-wide profitability was 10–20% [I05; I08; I11; I31; I32; I35]. Thus, some companies whose investment costs were lower than average would still invest under a curtailment rate of 20% [I01; I03]. Additionally, since the prices of wind power were mostly fixed by NDRC – known as benchmark prices – the total profit was in theory positively related to investment scale [I12; I18]. Moreover, like other power industries, achieving economies of scale was crucial to the wind power developers in order to lower overall cost [I07; I18]. As a result, they had to increase their investment scale as much as possible for future profit.

High-quality wind resources were scarce due to limited land availability to build wind farms. The Sanbei region was consequently in great demand by wind power developers. Interviewees reflected that to achieve sustainable profitability of wind farms, the Sanbei region held an unparalleled position compared to the southern and eastern regions, which encountered less wind curtailment. Wind power projects in the Sanbei region came first if the developers had to choose [I24; I32; I34].

Therefore, CSOEs competed fiercely over potential wind farm sites – a single site could attract a dozen of developers [I06; I08; I09; I34]. The competition among the largest energy CSOEs was particularly intense as they were considered neck-and-neck in the market [I06; I08; I12]. They were afraid of losing competitiveness and being left behind by peer enterprises. Thus, they set annual installation targets, in addition to profitability goals, as direct measures to boost competence and market power [I08; I18; I25; I26]. This pressure further encouraged CSOEs to increase investment scale in order to demonstrate their strong capabilities and gain the edge among peer CSOEs [I24].

Unfortunately, since severe wind curtailment undermined the profitability of wind power projects in the Sanbei region, investment decisions became challenging for CSOEs. On the one hand, if they kept investing in wind power, they might suffer from profit loss. On the other hand, to stop investing meant that they had to give up future market share and economic gains in the competition. However, we discovered that most studied CSOEs chose to keep investing because they strongly believed that wind curtailment was a temporary issue that could be solved eventually by the central government [I06; I08; I24; I25; I26]. One CSOE chose to stop investing in the Sanbei region as they were pessimistic about the situation of wind curtailment [I09; I18]. And due to the intensive competition among the largest CSOEs, first-mover advantages were crucial to increasing market share. They had to secure the development rights as fast as they could, or other competitors would get the projects immediately [I32].

Evidence showed that CSOEs were fully aware of the local wind curtailment situation. The developers were required to ask the local branches of the State Grid or regional power grid for the permission of grid-connection in the government's approval procedures. As the decision-maker of wind curtailment, the State Grid would provide an agreement to the developers before the grid-connection approval to ensure they would accept wind curtailment in power generation. Normally, CSOEs would accept the agreement [I30].

4.2.2. Adjusting the internal rate of return (IRR) to serve investment strategy

The investment strategies of CSOEs could be served by adjusting the internal rate of return (IRR) [I34], even though it is a standard financial evaluation method for wind power development, as introduced earlier in Section 2. It was not unusual that IRR calculations were manipulated intentionally, usually through underestimating the wind curtailment rate, to expand investment opportunities in the Sanbei region [I12; I32].

The actual calculation of IRR was complicated [F03; F04]. In practice, however, there were several key factors influencing the value of project IRR, including wind resource quality, expected utilization hours, on-grid price, financing cost, and land cost [I06; I08]. The relationship between IRR and these key factors can be expressed as:

$$\mathrm{IRR} = \frac{\textit{Wind resource} \times \textit{On}-\textit{grid price} \times \textit{Theoretical utilization hour}}{\textit{Total cost} \times \quad \textit{Technical utilization loss} \times \textit{Expected wind curtailment}}, \tag{5}$$

where,

$$\textit{Expected utilization hours} = \textit{Theoretical utilization hours} \times \textit{Coefficient of technical utilization loss} \times (1 - \textit{Expected wind curtailment rate}) \tag{6}$$

Eq. (5) show that the factors above were positively related to IRR while the factors below were negatively related. Eq. (6) calculated the expected utilization hours of a wind power project [F05; F06; F07]. Theoretical utilization hours referred to the utilization hours of a wind farm in full operation without energy loss from technological and climate impacts. And the coefficient of technical utilization loss referred to the actual percentage of utilization, counting the above energy loss. The expected wind curtailment rate was estimated by the developers. The IRR of a wind project is positively related to the expected utilization hours. Lower expected utilization hours resulted in a smaller IRR.

Among the key factors, wind resources, on-grid price, theoretical utilization hours, and total cost were foreseeable and easier to control for at a specific wind farm site [I12]. General wind resource conditions were largely invariable for biophysical and geographic reasons. On-grid price is determined by NDRC in the name of benchmark pricing, and then contracted with local power grid companies. The price is usually stable and negotiable within a certain range except for significant price adjustments, determined from above. Theoretical utilization hours were determined by wind resources and features of the wind power equipment. Companies estimated the technical utilization loss based on engineering and other technical issues, resulting in about a 20–30% decrease in the theoretic utilization hours [F05; F06]. Costs could also be controlled by companies themselves, including financing cost (e.g., interest rate of bank loans), land cost (e.g., costs for land development and right to use), construction and equipment purchasing, and installation. All in all, however, wind curtailment was the greatest uncertainty confronted by wind projects.

The interviewees from CSOEs admitted that the estimation was frequently inaccurate due to the difficulties in forecasting wind curtailment [I06; I08; I09; I12]. And this gave them an opportunity to manipulate the expected utilization hours. Conservative estimation of the expected wind curtailment rate was a default method used by the studied CSOEs. The common method applied was to take the average wind curtailment rate or utilization hours from the previous 2–3 years, or to use the latest provincial average curtailment rate released by the NEA [I06; I08; I12]. The CSOEs estimated wind curtailment based on the past, or if available, the current curtailment situation; none forecasted rising curtailment rates for their IRR calculations. In some cases, wind curtailment was not even considered in the decision-making.

For example, a large wind power project was placed in a city in Xinjiang province, where wind curtailment intensified sharply: in 2012, the curtailment rate was 10%; it reached 20% a year later and was close to 50% by 2016. The feasibility report [F05] for this project was submitted in May 2014 without any discussions of wind curtailment and its likely impact on the project's profitability (despite the fact that wind curtailment as a national phenomenon had existed for several years already). The assessment ended up with an IRR of 9%, exceeding the minimum requirement of 8%. The wind farm finished installation and began production in 2015. According to the sensitivity analysis of the project, 10% less utilization hours would have led to an IRR of less than 8%. In other words, if the company had accounted for wind curtailment, this project would not have been considered suitable for investment.

4.2.3. Utilizing timing strategy to secure development rights with lowest cost

Nevertheless, CSOEs did not increase their investment scale at all costs. Since their priority was to own more wind resources or potential wind farm sites in the Sanbei region, they utilized a strategy that could secure the development rights of the projects with the lowest cost. Developers had to be approved by the government for the development right of wind farm sites before construction and installation. The primary purpose of the development right was to legally guarantee the ability to use the land (NEA, 2011), which is a prerequisite for wind power generation. Location and land size significantly influence the quality and profitability of wind farms [I01; I07]. Therefore, acquiring land became a necessary step for increasing investment scale.

In light of this consideration, CSOE decision-making under wind curtailment was a two-stage process (Fig. 5: Step C&E). Companies at stage one (Step C) made the decision of whether or not to develop the chosen wind farm sites. Once the decision was made, companies began to prepare for the administrative procedures required by the government and for wind farm construction. Companies acquired development rights at stage one. At stage two (Step E), they made the decision of whether to install and generate power.

Thus, CSOEs adopted a strategy that aimed to increase land availability/development rights as much as possible. Before wind curtailment became an issue, companies tried to accelerate the development process as power generation brought immediate revenue: there was little to no waiting time between stage one and stage two [I23]. Wind power projects even competed with each other in terms of shorter installation periods [I23]. However, as wind curtailment conditions worsened, CSOEs began to rationally postpone installation to avoid further costs and potential losses, as major investments happened at stage two [I02; I04; I06; I26; I36]. Nevertheless, securing land availability was still a priority, necessary for maximizing market share. Therefore, CSOEs still made the decision to acquire development rights and wait to continue until the curtailment problem was solved or until conditions improved to the point where profitability returned [I25]. By this means, CSOEs could hold the development rights of wind resources without paying the costs of construction and installation.

However, despite their incentivization of investment, government regulations often impeded this timing strategy and urged CSOEs to move to installation [I26; I36; I38] – the ultimatum being that they would otherwise lose their development right. It therefore became a kind of “seesaw game” between the local government and developers. When CSOEs failed to delay installation after bargaining with the local government, they chose to install even though they would suffer from profit loss.

There were three major constraints to this timing strategy. First, developers must begin construction two years after government approval according to NEA's wind power regulation (NEA, 2011). Governments could remand a company's development right if it exceeded the time requirement. Second, the local government usually pressured developers to complete construction and installation as fast as possible because the former must complete annual investment targets, which were a critical component of local GDP growth [I05]. If the developer delayed, the local government could withdraw economic incentives and deny the company other business opportunities within its jurisdiction [I09; I18]. Since market competition was intense, companies were frequently compelled to accept such a deal. Third, NDRC lowered the wind power benchmark prices in recent years. For instance, in 2014, it was decided that the lower prices applied to onshore wind power projects approved after January 1st, 2015 or projects approved before January 1st, 2015 but producing after January 1st, 2016 (NDRC, 2014a).

Companies in wind curtailment regions therefore faced a dilemma: to keep waiting or install immediately and minimize potential economic losses from the lower price. Either decision was costly. If the company failed to bargain with the local government for an extended waiting time – hopefully until curtailment conditions improved – it had to accept the lower price eventually [I08], on pain of losing its development right. Nonetheless, even if the company completed the installation before the deadline, it still suffered economically due to wind curtailment. Developers were therefore forced to choose the lesser of two evils, usually based on their relationship with the local government [I08; I27]. Some local branches of CSOEs preferred immediate installation [I21; I22] due to their lack of confidence in being able to persuade the local government [I08; I09]. Immediate installation became a way to secure the development right, which was judged to be more important than the inevitable short-term costs from wind curtailment.

5. Discussion

The type of behavior identified in the research findings seems to go against the widespread conclusions of SOE studies as reviewed previously in Section 2. To sum up, CSOEs continuing to invest despite wind curtailment did not deviate from economic rationality – that is, following the market logic of profit maximization. As a matter of fact, it plays a crucial role in the wind investment decision-making process. Their investment decision-making was endogenous without direct political mandates from the central government. And the decision-making procedures they developed (Fig. 5) were sophisticated for risk and quality control purposes. They also established corporate policies to make sure the investment complied with good economic performance.[12]

CSOEs competed over scarce resources in order to enlarge market share and maximize long-term profits, leading to the surge of installation under wind curtailment. CSOEs believed that the wind power market would be very promising in the long run since wind power is an important substitute for fossil fuels, being central to China's commitment to mitigate climate change by promoting renewable energy. Increasing investment scale was cost-effective and was expected to bring tremendous economic returns sooner or later. However, since wind curtailment heightens risks to wind power investment, CSOEs deployed timing strategies to avoid the profit loss caused by wind curtailment. And even if they failed to do so, the inevitable loss would only be temporary and merely a cost that they had to pay in order to

[12] For example, benchmarking schemes and improve minimum IRR requirement introduced in Section 4.1.2.

secure development rights.

In this regard, SOEs behave somewhat differently than private sector corporations, as strictly private firms would likely not survive the short-term losses associated with such levels of wind curtailment, but the actual motivation behind their investment decisions is similar, namely long-term profit maximization. Therefore, the traditional conclusions about SOEs – that they are merely instruments of government prerogatives, and motivated chiefly by political pressure – cannot fully explain the investment behavior of CSOEs in wind power development.

However, unlike for private corporations, CSOEs' tendency to follow market logic was not inherent but created by the central government as a result of China's economic reforms. The economic rationality they showed was by design from the central government through several rounds of SOE reforms (Dai, 2016). The traditional take on SOEs was indeed valid for several decades, particularly before China's reform and opening-up in the late 1970s. However, since 1984, SOEs have been pushed to act increasingly in accordance with market economy principles, including business autonomy, economic independence and market competition to improve efficiency (Johns, 1995; Perkins, 1994).[13] China's economic reforms fundamentally changed the government-SOE relationship (Naughton, 2017). Under it, SOEs, as the foundation of China's "socialist market economy," are responsible for making profit for the state (Milhaupt and Zheng, 2015). The central government established the "modern enterprise system" to grant SOEs more autonomy and incentivize SOEs to be more efficient and productive (Yu, 2014). As a result, SOEs have been expected to stay separate from bureaucratic concerns and operate as modern firms with the separation of ownership and control (Lin et al., 1998). And facilitating the market competitiveness of SOEs was an important consideration of the economic reforms (Mcmillan and Naughton, 1992).

In order to monitor and evaluate SOEs in terms of their economic performance, the State-owned Assets Supervision and Administration Commission of the State Council (SASAC) was established in 2003 to exercise the government's powers of ownership (Naughton, 2006a). SASAC has the authority over SOEs in terms of the rights and responsibilities of public ownership, as well as in setting the strategic orientation of these enterprises (Naughton, 2006a, 2017). And SASAC has been divided into two tiers based on central and local government ownership. The central SASAC exercises ownership of the CSOEs (Naughton, 2006b).

CSOEs were required and incentivized by the central SASAC to generate financial gains. They were expected to become profitable (Dai, 2013; Szamosszegi and Cole, 2011). The SASAC issued, "The business performance evaluation for the central state-owned enterprises' executives" in 2012 (SASAC, 2012). The SASAC evaluated CSOEs for both yearly and 3-year term performances mainly based on total profit and Economic Value-Added (EVA), which would directly determine the reward and punishment for these executives in terms of both economic and political gains.

The economic reform also had a strong impact on the power industry. The State Council issued the power sector reform plan in 2002 (State Council, 2002), which aimed at creating a market for the power sector and to encourage market competition to improve the efficiency of electricity generation in China (Chen, 2010; Yeh and Lewis, 2004). The power reform drastically changed the situation of the State Power Corporation which had monopolized the power supply. It separated power grid and generation businesses and broke the centralized and integrated system into two power grid CSOEs, five power generation CSOEs (the "Big Five") and several other institutions (Xu and Chen, 2006). The competition we observed among CSOEs resulted from these major reforms.

The market, however, is constrained by administrative hurdles. Although the power supply is no longer monopolized by a single player, the power market is still regulated in general. The benchmark prices are mostly determined by NDRC and electricity generation planning is mostly adopted instead of determined by free market transactions between power plants and users.[14] And the government subsidizes wind power industries heavily. The massive development of wind power in the Sanbei region was built on the optimistic forecast of power demand growth. However, the economic "new normal" of China decreased the actual demand for power (Dong et al., 2018; Qi et al., 2018). As a result, there has been a mismatch of wind power supply and demand, which is one key reason for wind curtailment (Qi et al., 2018; Yang et al., 2012)

Power generation in China remains dominated by the central state-owned oligopolies. These players compete fiercely within the constrained market, responding to evaluations from the central government. It is, without doubt, different from a competitive market where the government is neutral and only acts as an enforcer of market rules. CSOEs, in contrast, benefit from preferred access to bank capital, below-market interest rates on loans and other preferences (Szamosszegi and Cole, 2011). These "soft budget constraints" (Chow et al., 2010; Guriev, 2018) could explain why CSOEs were able to increase their investment scale and bear the cost of wind curtailment better than fully private companies. Their evolution within this system might explain the behavioral characteristics of wind power CSOEs in China, which are increasingly but not entirely market-oriented.

6. Conclusion and policy implications

Though wind curtailment significantly jeopardizes wind power development and developers' profitability in China, we observed that companies continued to invest despite the increasingly severe wind curtailment. This research tried to explain this paradox by using a qualitative, exploratory approach. Since the majority of wind power investments are made by CSOEs, one could assume that their investment decisions represent merely a "policy burden", following the widely assumed hypothesis of SOE studies (Lin, 1999; Lin et al., 1998; Lin and Tan, 1999). However, this study shows that CSOEs' investment behavior can be better explained as a specific form of economic rationality.

As they competed fiercely over wind power sites in the Sanbei region, increasing investment scale was an economically rational strategy. Admittedly, this is due in part to the fact that these firms can count on privileged forms of support from the government. The embrace of market logic by CSOEs is an effect of long-term government efforts to reform the Chinese economy, and specifically its power sector. The purpose was to incentivize CSOEs to increase financial performance and production. The market is still constrained by design with fixed power costs, privileged support, and large oligopolies, all of which help explain the current mix of behavioral characteristics.

We conclude that current academic studies have generally underestimated market influence on SOEs, and that economic rationality plays a larger role than previously acknowledged. This study does not aim to overturn the mainstream view of the existing literature, but to supplement it by identifying and analyzing the under-appreciated role of market logic in SOE investment decisions. In addition, researchers seldom incorporate SOE research into mainstream firm theory. Rather, they consider SOEs as a marginal and special case (Peng et al., 2016).

[13] The third Plenary Session of the 12th CPC (Communist Party of China) Central Committee in 1984 first announced to separate the control of the government and business operations and decisions of SOEs. The 14th National Congress of CPC in 1992 stated clearly that SOEs were encouraged to participate in fair market competition. And in 2002 the 16th National Congress of CPC first announced to bring market competition to monopoly industries.

[14] A new round of power market reform has begun since 2015. This new reform aims to establish a free trading system in the power sector. Pilot cities have been selected to experiment with power trading markets, which allow the suppliers and users to trade freely at market prices.

This study shows that there is a lot to learn from applying traditional market theories to markets in transition such as the Chinese power sector, and that fine-grained qualitative research of SOEs has the potential to provide both theoretically substantive information and detailed empirical analysis.

This study also provides strong implications for wind power policy-making and solutions for the wind curtailment issue in China. Instead of emphasizing market growth, policy-makers should pay more attention to the negative impacts and the quality of the competition. One the one hand, the market logic, or economic rationality, of CSOEs has facilitated a significant growth of the wind power industry. On the other hand, intense competition among CSOEs has jeopardized businesses' healthy and natural development, further exacerbating wind curtailment in the Sanbei region. The competition has, to some extent, been distorted by industrial policies such as the wind power benchmark price, time limits on installations, and, more importantly, favorable market access for CSOEs. Policy-makers should fully understand the investment logic of CSOEs and alter policies that would interrupt the wind power market. The government must act more as a strict but neutral regulator. More importantly, more efforts should be made to facilitate the demand-side reform of the power market. Policy-makers should deploy multiple instruments to allow the market to determine the level of the demand. This will give greater play to market forces, including upon CSOEs, and help ensure a more sustainable environment for wind power investment.

Appendix A. Interview list

Interview Code	Positions	Date	Location	Type
I01	A power expert from a CSOE	May 2016	Beijing	Face-to-Face
I02	A renewable energy industry analyst of an investment bank	May 2016	Beijing	Via phone
I03	A renewable energy industry analyst of an investment bank	May 2016	Beijing	Via phone
I04	A renewable energy industry analyst of an investment bank	May 2016	Beijing	Via phone
I05	An executive-level decision-maker of Chinese Wind Energy Association	June 2016	Beijing	Face-to-Face
I06	A renewables-related decision-maker of CSOE A	June 2016	Beijing	Face-to-Face
I07	A senior engineer of CSOE A	June 2016	Beijing	Via phone
I08	A renewables-related decision-maker of CSOE B	June 2016	Beijing	Face-to-Face
I09	A Vice President and a financial officer of CSOE C	June 2016	Beijing	Face-to-Face
I10	A policy-maker of renewable energies	June 2016	Beijing	Face-to-Face
I11	A middle-level manager of a large private wind power company	June 2016	Beijing	Questionnaire
I12	A financial officer of CSOE D	July 2017	Beijing	Face-to-Face
I13	A middle-level manager of the State Grid Gansu Company	August 2016	Gansu province	Face-to-Face
I14	An official of the renewable energy department of the J city government	August 2016	Gansu province	Face-to-Face
I15	An upper-level manager of a regional branch office of CSOE C	August 2016	Gansu province	Face-to-Face
I16	A power planning-related official of the Gansu government	March 2017	Gansu province	Questionnaire
I17	A middle-level manager of the State Grid Gansu Company	March 2017	Gansu province	Face-to-Face
I18	Two upper-level managers of a regional branch office of CSOE C	July 2017	Gansu province	Face-to-Face
I19	An operations officer of a local wind farm of CSOE C	July 2017	Gansu province	Face-to-Face
I20	An upper-level manager of a local wind farm of CSOE D	July 2017	Gansu province	Face-to-Face
I21	An upper-level manager and a senior employee of a local wind farm of CSOE F	July 2017	Gansu province	Face-to-Face
I22	An upper-level manager of a local wind farm of CSOE B	July 2017	Gansu province	Face-to-Face
I23	A middle-level manager of a local wind farm of CSOE G	July 2017	Gansu province	Face-to-Face
I24	An upper-level manager of a regional branch office of CSOE A	July 2017	Gansu province	Face-to-Face
I25	An upper-level manager and a senior engineer of a regional branch office of CSOE B	July 2017	Gansu province	Face-to-Face
I26	A middle-level manager of a regional branch office of CSOE G	July 2017	Gansu province	Face-to-Face
I27	An official of the energy department of Gansu province; an executive official of the energy department of J city	July 2017	Gansu province	Face-to-Face
I28	An executive official of the energy department of G county, J city.	July 2017	Gansu province	Face-to-Face
I29	Two middle-level managers of the branch office of the State Grid in J city	July 2017	Gansu province	Face-to-Face
I30	A middle-level manager of the State Grid Gansu Company	July 2017	Gansu province	Face-to-Face
I31	An upper-level manager and a senior engineer of a wind farm of CSOE B	April 2017	Guizhou province	Face-to-Face
I32	An upper-level manager of a local branch office of CSOE D	June 2017	Hubei province	Face-to-Face
I33	A senior engineer and two employees of the above branch office of CSOE D	June 2017	Hubei province	Face-to-Face
I34	An upper-level manager of a local branch office of CSOE E	June 2017	Hubei province	Face-to-Face
I35	An executive official of the Bureau of Development and Reform of L district, Y city	June 2017	Hubei province	Face-to-Face
I36	4 upper-level managers of a local private wind power	June 2017	Hubei province	Face-to-Face
I37	A senior employee of the branch office of the State Grid in Y city	June 2017	Hubei province	Face-to-Face
I38	An official of the energy department of Y city	June 2017	Hubei province	Face-to-Face

*CSOE A, B, D, G were the "Big Five"-a term referring to the five largest power CSOEs in China. CSOE C, F were the "Small Four"-a term referring to four smaller power CSOEs comparing to the "Big Five". CSOE E was a pioneer investor in wind power.

Appendix B. Documents provided by the interviewees

Document code	Title	Description
F01	Preliminary work management of Wind power projects for Company X (headquarter)	It is a handbook for the early stage of wind power projects. It provides the instructions to develop wind power projects and clarifies the decision-making process of the projects.
F02	Preliminary work management of Wind power projects for Company X (subsidiary for renewable energy business)	Same as above
F03	Financial calculating model for project investment (renewable energy) of Company X	It is an excel file for financial calculating purposes. The financial model calculates the internal rate of return (IRR) of wind power projects as the bases of the investment decision-making.
F04	Financial calculating model for wind power project investment of Company X	Same as above
F05	Feasibility report of wind project X in Xinjiang province (2014)	The feasibility report of a wind project investment with comprehensive information on this project including resource assessment and profitability projection.
F06	Feasibility report of wind project X in Hubei province (2015)	Same as above
F07	Preliminary design report of wind project X in Guizhou province (2016)	The early version of feasibility report
F08	The reports of wind power companies for NEA's closed-door meeting in Gansu (2017)	The reports of 6 wind power companies based in Gansu province (CSOE branches and large private companies) for the meeting. The reports introduce the current status and obstacles of these companies.
G01	The reports of local governments on wind power development in Gansu province for NEA's closed-door meeting (2017)	The reports of 5 local governments on wind power development and wind curtailment issues
G02	Gansu power market report for the first half year of 2017	A report on Gansu's power market transactions with comprehensive information of wind power market

*Company X refers to the CSOE that provided this document.

References

BJXnet, 2014a. Major wind power developers in China (In Chinese). Available from: ⟨http://news.bjx.com.cn/html/20141212/572965.shtml⟩.

BJXnet, 2014b. Why did companies build more wind farms under worsen wind curtailment? (In Chinese). Available from: ⟨http://news.bjx.com.cn/html/20140508/509254-2.shtml⟩.

BJXnet, 2015. How to solve the problem of wind power subsidies not appropriating on time (In Chinese). Available from:⟨http://news.bjx.com.cn/html/20151020/673360.shtml⟩.

BJXnet, 2017. China’s wind industry is trapped in the loop of installation under curtailment (In Chinese). Available from: ⟨http://news.bjx.com.cn/html/20170206/806417.shtml⟩.

Brady, H.E., Collier, D., 2010. Rethinking Social Inquiry: Diverse Tools, Shared Standards. Rowman & Littlefield.

Chen, L., 2010. Playing the market reform card: the changing patterns of political struggle in China's electric power sector. China J. 69–95.

China Economy Net, 2013. Local government’s protectionism in wind power development and increasing wind curtailment issue (In Chinese). Available from: ⟨http://www.ce.cn/xwzx/gnsz/zg/201303/08/t20130308_24180365.shtml⟩.

Chinese Electric Power Yearbook Committee, 2001. Chinese Electric Power Yearbook (In Chinese). Chinese Electric Power Press, Beijing.

Chinese Electric Power Yearbook Committee, 2007. Chinese Electric Power Yearbook (In Chinese). Chinese Electric Power Press, Beijing.

Chow, C.K., Song, F.M., Wong, K.P., 2010. Investment and the soft budget constraint in China. Int. Rev. Econ. Financ. 19, 219–227.

Clò, S., Del, Bo, C., Ferraris, M., Fiorio, C.V., Florio, M., Vandone, D., 2015. Publicization versus Privatization: Recent Worldwide Evidence. Social Science Electronic Publishing.

Dai, J., 2013. Reform of Property Right, Competition Environment and Policy Instrument: the Reflection of Theory of State-Owned Corporate Reform. Reform.

Dai, J., 2016. Chapter 2 SOE's role as policy instruments. The Nature of the State-Owned Enterprises. Economic Science Press.

Daiser, P., Ysa, T., Schmitt, D., 2017. Corporate governance of state-owned enterprises: a systematic analysis of empirical literature. Int. J. Public Sect. Manag. 30.

Dan, M., 2009. Government Intervention, Soft Budget Constraint and Over-investment——With the Data of State-owned Listed Companies from 2004 to 2006. Soft Science.

Davidson, Michael R., Zhang, D., Xiong, W., Zhang, X., Karplus, Valerie, J., 2016. Modelling the potential for wind energy integration on China's coal-heavy electricity grid. Nat. Energy 1, 16086.

Dong, C., Qi, Y., Dong, W., Lu, X., Liu, T., Qian, S., 2018. Decomposing driving factors for wind curtailment under economic new normal in China. Appl. Energy 217, 178–188.

Dong, X.Y., Putterman, L., 2003. Soft budget constraints, social burdens, and labor redundancy in China's state industry. J. Comp. Econ. 31, 110–133.

Du, J., Wang, Y., 2013. Reforming SOEs under China’s State Capitalism in Unfinished Reforms in the Chinese Economy.

Fan, J.P., Wong, T.J., Zhang, T., 2007. Politically connected CEOs, corporate governance, and Post-IPO performance of China's newly partially privatized firms. J. Financ. Econ. 84, 330–357.

Groves, T., Hong, Y., McMillan, J., Naughton, B., 1994. Autonomy and Incentives in Chinese State Enterprises. Q. J. Econ. 109, 183–209.

Guriev, S., 2018. Soft budget constraints and state capitalism. Acta Oeconomica 68, 115–124.

Hawkins, R.L., Maurer, K., 2009. Bonding, bridging and linking: how social capital operated in new Orleans following Hurricane Katrina. Br. J. Soc. Work bcp087.

Huchet, J.F., 2003. Review: state-owned Enterprise Reform in China by Justin Yifu Lin; Fang Cai; Zhou Li. China J. 50, 200.

Ifeng News, 2009. The State Electricity Regulatory Commission investigation: profit loss of wind farms is very common in China (In Chinese). Available from: ⟨http://finance.ifeng.com/roll/20090723/978854.shtml⟩.

Ifeng News, 2011. China Electricity Council: Profit loss of wind power first showing this year (In Chinese). Available from: ⟨http://news.ifeng.com/gundong/detail_2011_08/23/8600667_0.shtml⟩.

Johns, D.K., 1995. Reforming the State-Enterprise Property Relationship in the People’s Republic of China: The Corporatization of State-Owned Enterprises. Mich.j.intl L.

Kalfagianni, A., Kuik, O., 2016. Seeking optimality in climate change agri-food policies: stakeholder perspectives from Western Europe. Clim. Policy 1–21.

Koppell, J.G., 2007. Political Control for China’s State-Owned Enterprises: Lessons from America’s Experience with Hybrid Organizations.

Kornai, J., 1986. The soft budget constraint. Kyklos 39, 3–30.

Lewis, J.I., 2016. Wind energy in China: Getting more from wind farms. Nat. Energy 1, 16076.

Li, S., Lin, Y.C., Selover, D.D., 2014. Chinese state-owned enterprises: are they inefficient? Chin. Econ. 47, 81–115.

Liao, G., Chen, X., Jing, X., Sun, J., 2009. Policy burdens, firm performance, and management turnover. China Econ. Rev. 20, 15–28.

Lin, J.Y., 1999. Policy burdens, soft budget constraint and state-owned enterprise reform in China.

Lin, J.Y., Cai, F., Li, Z., 1998. Competition, policy burdens, and state-owned enterprise reform. Am. Econ. Rev. 88, 422–427.

Lin, J.Y., Tan, G., 1999. Policy burdens, accountability, and the soft budget constraint. Am. Econ. Rev. 89, 426–431.

Lioukas, S., Bourantas, D., Papadakis, V., 1993. Managerial autonomy of state-owned enterprises: determining factors. Organ. Sci. 4, 645–666.

Liu, X., Shen, J.H., Deng, K., 2016. A rational path towards a Pareto optimum for reforms of large state-owned enterprise in China, past, present and future. Economic History Working Papers.

Liu, X., Wang, W., 2004. Overinvestment under Soft Budget Constraint and Barrier to Entry. Review of Industrial Economics.

Lu, X., McElroy, M.B., Peng, W., Liu, S., Nielsen, C.P., Wang, H., 2016. Challenges faced by China compared with the US in developing wind power. Nat. Energy 1, 16061.

Luo, G.-l., Li, Y.-l., Tang, W.-j., Wei, X., 2016. Wind curtailment of China′ s wind power operation: evolution, causes and solutions. Renew. Sustain. Energy Rev. 53, 1190–1201.

Luo, G.L., Zhi, F., Zhang, X., 2012. Inconsistencies between China's wind power development and grid planning: an institutional perspective. Renew. Energy 48, 52–56.

Mcmillan, J., Naughton, B., 1992. How to reform a planned economy: lessons from China. Oxf. Rev. Econ. Policy 8, 130–143.

Milhaupt, C.J., Zheng, W., 2015. Beyond ownership: state capitalism and the Chinese firm. Georget. Law J. 103, 665–722.

Morrison, T.H., 2017. Evolving polycentric governance of the Great Barrier Reef. Proc. Natl. Acad. Sci. USA 201620830.

Morsing, M., 2011. State-owned enterprises: a corporatization of governments? Manag. Commun. Q. 25, 710–717.

National Bureau of Statistics of China, 2016. China Statistical Yearbook, Beijing.
Naughton, B., 2006a. Claiming profit for the state: SASAC and the capital management budget. China Leadersh. Monit. 18, 1–9.
Naughton, B., 2006b. Top-Down Control: SASAC and the Persistence of State Ownership in China.
Naughton, B., 2017. The current wave of state enterprise reform in China: a preliminary appraisal. Asian Econ. Policy Rev. 12, 282–298.
NDRC, 2003. Administrative guidelines of pre-feasibility assessment for construction projects (In Chinese). Available from: 〈http://www.nea.gov.cn/2015-12/13/c_131051487.htm〉.
NDRC, 2009. NDRC announcement on wind power on-grid price policy (In Chinese). Available from: 〈http://www.ndrc.gov.cn/zcfb/zcfbtz/200907/t20090727_292827.html〉.
NDRC, 2014a. NDRC Bulletin for On-shore Wind Power Benchmark Price Adjustment (In Chinese). Available from: 〈http://www.ndrc.gov.cn/gzdt/201501/t20150109_659879.html〉.
NDRC, 2014b. NDRC wind power benchmark prices adjustment bulletin (In Chinese) Available from: 〈http://www.ndrc.gov.cn/gzdt/201501/t20150109_659879.html〉.
NDRC, 2015. NDRC solar and wind power benchmark prices adjustment bulletin (In Chinese). Available from: 〈http://www.ndrc.gov.cn/zcfb/zcfbtz/201512/t20151224_768573.html〉.
NDRC, 2016. NDRC solar and wind power benchmark prices adjustment bulletin (In Chinese). Available from: 〈http://www.ndrc.gov.cn/gzdt/201612/t20161228_833065.html〉.
NEA, 2007. Mid-long term strategy of renewable energy development (In Chinese). Available from: 〈http://www.ndrc.gov.cn/zcfb/zcfbghwb/200709/t20070904_579685.html〉.
NEA, 2011. Wind Power Development and Construction Provisional Procedures (In Chinese). Available from: 〈http://zfxxgk.nea.gov.cn/auto87/201302/t20130226_1583.htm〉.
NEA, 2013. NEA: The third approval list of wind power projects under 12th Five-Year-Plan (In Chinese). Available from: 〈http://www.gov.cn/zwgk/2013-03/19/content_2357381.htm〉.
NEA, 2016. 2015 Wind Power Development Conditions (In Chinese). Available from: 〈http://www.nea.gov.cn/2016-02/02/c_135066586.htm〉.
NEA, 2017a. NEA: wind power investment alerts in 2017 (In Chinese). Available from: 〈http://zfxxgk.nea.gov.cn/auto87/201702/t20170222_2604.htm〉.
NEA, 2017b. Wind power gird connection and operation in 2016 (In Chinese). Available from: 〈http://www.nea.gov.cn/2017-01/26/c_136014615.htm〉.
Netease, 2009. Wind power: the popular but profit-losing business (In Chinese). Available from: 〈http://news.163.com/special/00012Q9L/fengdian100318.html〉.
Pei, W., Chen, Y., Sheng, K., Deng, W., Du, Y., Qi, Z., Kong, L., 2015. Temporal-spatial analysis and improvement measures of Chinese power system for wind power curtailment problem. Renew. Sustain. Energy Rev. 49, 148–168.
Peng, M.W., Bruton, G.D., Stan, C.V., Huang, Y., 2016. Theories of the (state-owned) firm. Asia Pac. J. Manag. 33, 293–317.
Perkins, D., 1994. Completing China's Move to the Market. J. Econ. Perspect. 8, 23–46.
Qi, Y., Lu, J., Zhu, M., 2018. Wind curtailment in China and lessons from the United States. Available from: 〈https://www.brookings.edu/research/wind-curtailment-in-china-and-lessons-from-the-united-states/〉, Brookings Institution.
Qian, Y., Roland, G., 1996. The soft budget constraint in China. Jpn. World Econ. 8, 207–223.
Roper, J., Schoenberger-Orgad, M., 2011. State-owned enterprises issues of accountability and legitimacy. Manag. Commun. Q. 25, 693–709.
Ross, S.A., 1995. Uses, abuses, and alternatives to the net-present-value rule. Financ. Manag. 24, 96–102.
SASAC, 2012. The business performance evaluation for the central state-owned enterprises' executives (provisional) (In Chinese) Available from: 〈http://www.gov.cn/flfg/2013-02/01/content_2324949.htm〉.
Schroeter, E., Roeber, M., Roeber, J., 2016. Why do state-owned enterprises exist? The political rationale of public owNership, in: Proceedings of the 20th International Research Society on Public Management Conference Hong Kong.
Shu, Y., Zhang, Z., Guo, J., Zhang, Z., 2017. Study on Key factors and solution of renewable energy accommodation. In: Proceedings of the Csee, 37, pp. 1–8.
Sina, 2014. Profit loss of wind power projects (In Chinese). Avaiable from: (〈http://finance.sina.com.cn/roll/20141119/205420864737.shtml〉).
Sohu, 2017. Getting out of the loop: wind installation under curtailment (In Chinese) Available from: (〈http://mt.sohu.com/20170308/n482721885.shtml〉).
Starks, H., Trinidad, S.B., 2007. Choose your method: a comparison of phenomenology, discourse analysis, and grounded theory. Qual. Health Res. 17, 1372.
State Council, 2002. State Council Bulletin for Electric Power Institution Reform Plan (In Chinese) Available from: 〈http://www.gov.cn/zhengce/content/2017-09/13/content_5223177.htm〉.
Sun, Q., Zhang, A., Jie, L.I., 2005. A study of optimal state shares in mixed oligopoly: implications for SOE reform and foreign competition. China Econ. Rev. 16, 1–27.
Szamosszegi, A., Cole, K., 2011. An analysis of state-owned enterprises and state capitalism in China.
Vromen, A., 2010. Debating Methods: Rediscovering Qualitative Approaches.
Wang, F., Yin, H., Li, S., 2010. China's renewable energy policy: commitments and challenges. Energy Policy 38, 1872–1878.
Wang, J.Y., 2008. The political logic of corporate governance in China's state-owned enterprises. Cornell Int. Law J. 47, 631–669.
Wang, Z., Qin, H., Lewis, J.I., 2012. China's wind power industry: policy support, technological achievements, and emerging challenges. Energy Policy 51, 80–88.
Xiong, W., Wang, Y., Mathiesen, B.V., Zhang, X., 2016. Case study of the constraints and potential contributions regarding wind curtailment in Northeast China. Energy 110, 55–64.
Xu, L.C., 2010. Control, incentives and competition: the impact of Reform on Chinese state-owned enterprises. Econ. Transit. 8, 151–173.
Xu, S., Chen, W., 2006. The reform of electricity power sector in the PR of China. Energy Policy 34, 2455–2465.
Yang, M., Patiño-Echeverri, D., Yang, F., 2012. Wind power generation in China: understanding the mismatch between capacity and generation. Renew. Energy 41, 145–151.
Yeh, E.T., Lewis, J.I., 2004. State power and the logic of reform in China's electricity sector. Pac. Aff. 77, 437–465.
Yu, H., 2014. The Ascendency of state-owned enterprises in China: development, controversy and problems. J. Contemp. China 23, 161–182.
Yuan, Z., Shao, T., 2010. The Historic Position, Function and Further Reform of SOE. Academic Monthly.
Zhang, W., 2015. The Theory of the Firm and the Reform of Chinese Enterprises (In Chinese), First edition ed. Shanghai People's Publishing House.
Zhang, Y., 2016. Wind curtailment statistics from 2011–2015 (In Chinese). Wind Energy 34–35.
Zhang, N., Lu, X., Mcelroy, M.B., Nielsen, C.P., Chen, X., Deng, Y., Kang, C., 2016a. Reducing curtailment of wind electricity in China by employing electric boilers for heat and pumped hydro for energy storage. Appl. Energy 184, 987–994.
Zhang, Y., Tang, N., Niu, Y., Du, X., 2016b. Wind energy rejection in China: Current status, reasons and perspectives. Renew. Sustain. Energy Rev. 66, 322–344.
Zhao, X., Li, H., Wu, L., Qi, Y., 2014. Implementation of energy-saving policies in China: how local governments assisted industrial enterprises in achieving energy-saving targets. Energy Policy 66, 170–184.
Zhao, X., Ortolano, L., 2010. Implementing China's national energy conservation policies at state-owned electric power generation plants. Energy Policy 38, 6293–6306.
Zhao-Yang, X.U., 2014. State-Owned Enterprises as Policy Instruments and SOE Reform: Perspective of Soft Budget Constraint. China Soft Science.
Zif, J., 1981. Managerial strategic behavior in state-owned enterprises—business and political orientations. Manag. Sci. 27, 1326–1339.