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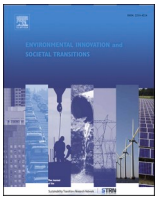

Research article

How do incumbent companies' heterogeneous responses affect sustainability transitions? Insights from China's major incumbent power generators

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ABSTRACT

Transitions research has often been unintentionally biased toward novelty and assumes incumbents as homogeneous groups that are "locked-in" to certain sociotechnical regimes. In reality, incumbents are heterogeneous at the company and industrial levels and thus have heterogeneous responses that can both accelerate and deter sustainability transitions. To fill the research gap, this paper explores the determinants of such heterogeneous responses and insights for sustainability transitions, taking China's major incumbent power generators as its case study. The results are: first, incumbent companies respond heterogeneously if firm-specific, socioeconomic, and institutional factors give different opportunities and barriers. Policy feedback effects and development of complementarities in infrastructure, instruments, and organizational elements can increase heterogeneous responses. Second, their heterogeneous responses can accelerate sustainability transitions if they go beyond destabilization of regime, legitimization of alternative policy instruments, and development of infrastructure and institutions that trigger coevolution with socioeconomic and institutional factors.

1. Introduction

Achieving the ambitious climate goals set out in the Paris Agreement calls for fundamental changes in the electricity system (International Energy Agency (IEA, 2019). Though electric utilities play an important role in ensuring a successful energy transition, the sector is dominated by large incumbent companies that may show reluctance to change. How these companies adapt their business strategies and portfolios can play a decisive role in the direction and speed of transitions (Frei et al., 2018).

Transitions research tends to anticipate the specific pathway whereby radical innovation emerges in niches, builds up internal momentum by learning processes, improves price/performance for breakthroughs, and overthrows the existing regime in a specific way (Smith and Raven, 2012). Recently, the "flip sides" to innovation, including destabilization and discontinuation of the socio-technical system (Turnheim and Geels, 2012), have received increasing attention as another factor. Decline, purposeful destabilization, and phasing-out of undesirable technologies and systems are required to accelerate sustainability transitions (Markard, 2018). A continuous increase in external pressures and either economic or legitimacy problems can also incentivize vested interests to unlock routines, technical capabilities, mind-sets and strategic missions, and loosen their commitment to existing regimes (Berggren et al., 2015; Geels and Penna, 2015; Kungl and Geels, 2018). Some of them are prompted to either reorient toward radical niche innovations (Berggren et al., 2015; Geels and Penna, 2015), move into different sectors to engage with niche innovations (Hess, 2014),

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or recombine and diversify their businesses (Andersen and Gulbrandsen, 2020).

Still, the research tends to assume incumbents as homogeneous groups that are "locked-in" to socio-technical regimes, and that use instrumental, discursive (Lee and Hess, 2019; Trencher et al., 2019), material (Hess, 2014), and institutional (Fünfschilling and Truffer, 2014; Smink et al., 2015) forms of power to impede transitions or restrict changes within a particular regime (Stirling, 2014).

In reality, incumbents are heterogeneous at the company and industrial levels. They differ by type, context, challenges, and perceptions (Turnheim and Sovacool, 2020). They pursue their own goals and have their own decision-making styles, scales of operation, and technologies along with their own dynamics, time horizons, and speeds of development (Markard and Hoffmann, 2016). They have different incentives and opportunities in radical and sustainable innovations (Wesseling et al., 2015). Characteristics of industries build sector-specific opportunities and barriers for low-carbon innovation (Wesseling et al., 2017).

To deepen our understanding of how incumbent companies' heterogeneous responses affect sustainability transitions, we pose two research questions:

(1) What are the factors that contribute to the incumbent companies' heterogeneous responses?
(2) What are the implications of their heterogeneous responses to sustainability transitions?

To answer these questions, this paper first develops an encompassing analytical framework that accounts for institutional, socio-economic, and firm-specific causes of heterogeneity based not only on energy transition literature but also business strategy and organizational studies. We then apply this framework to China's major incumbent power generators to conduct an empirical case study.

Our focus on China aims to generalize the responses of incumbent companies by going beyond the European context. The literature on regime resistance has explored the strategy of regime incumbents mostly on the basis of case studies of Germany (Kungl, 2015; Rogge and Johnstone, 2017; Kungl and Geels, 2018; Leipprand and Flachsland, 2018; Oei et al., 2019), the United Kingdom (Turnheim and Geels, 2012, 2013; Geels et al., 2016; Johnstone et al., 2017; Lockwood et al., 2019), Norway (Heiskanen et al., 2018; Andersen and Gulbrandsen, 2020), and the Netherlands (Bosman et al., 2014). Recent studies have covered cases beyond European countries, and some have conducted cross-country analyses, yet only a few studies have examined Asian cases. This is understandable given that most Asian countries are still increasing their installation capacity of coal power. However, in China, power generators have shifted their focus toward new and renewable energy in response to the government mandates on the reduction of coal use (Lin et al., 2019). Yet, these shifts have been restricted by the major state-owned grid companies that act as enablers of smart grid deployment while blocking structural changes in socio-technical regimes (Mah et al., 2017).

This paper has two main contributions. First, it builds an analytical framework that explains incumbent companies' heterogeneous responses covering both proactive and negative responses, and their implications for sustainability transitions. Second, it adds some empirical novelty to the factors that generate incumbents' heterogeneous responses and the effectiveness of incumbents' heterogeneous responses on sustainability transitions.

The remainder of this paper proceeds as follows. The next section builds an analytical framework that explains the relationship between the incumbents' heterogeneous responses and the underlying factors. Section 3 presents the methodology for case studies and the logic behind the case selection. Section 4 provides the results of the analysis, and Section 5 discusses what enables heterogeneous responses to accelerate sustainability transitions. Finally, Section 6 concludes the paper and provides suggestions for future research.

2. Analytical framework

In reference to Steen and Weaver (2017), we conceptualize incumbent companies as being profit-seeking actors that are 'established' and 'positioned' in markets. They tend to affect and be affected by socio-economy in their locations, policy, and institutions.

We examined diverse literature, including that of sustainability transitions, climate and energy policy, firm management, economics, and political economy. We identified relevant studies using a two-step approach: (i) searching on Web of Science and Scopus with various combinations of the following keywords: "energy transitions," "corporate strategy," "organizational strategy," "diversification," and "incumbents," with the time scope between 2015 and 2020 and the categories of political science, economics, management, public administration, business, and regional urban planning; and (ii) we examined the resulting hits to identify additional references. At the first stage, we retrieved 268 papers (187 from Scopus and 81 from Web of Science). Then we manually excluded duplications and omitted entries that were too broad from the subject of energy or socio-technical transitions, while adding journal articles to cover studies dealing explicitly with corporate or organizational responses to energy or socio-technical transitions, as well as those discussing factors that shape strategic choice and management commitment. The final stage resulted in 48 papers. We used 41 papers to build an analytical framework and others to present research gaps in the introduction.

2.1. Typology of heterogeneous responses

In reference to Lauber and Sarasini (2015), we categorized the incumbent companies' responses into adaptation and advancing reorientation, horizontal diversification, staying inert, and weaker reorientation. Incumbent companies tend to advance reorientation when a continuous increase in external pressures becomes so powerful that the system is destabilized and the companies' resistance strategies lose legitimacy. They leverage their resources and capabilities to reorient for innovation to capture value in new niche sectors in both domestic and international markets (Steen and Weaver, 2017).

Incumbent companies may take horizontal diversification and external expansion of core businesses by establishing emerging

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businesses or form new social contacts with new entrants to overcome challenges related to organization of innovation and production (Rogge and Johnstone, 2017; Andersen and Gulbrandsen, 2020). They enhance a trader's skillset to manage new challenges and provide a hedge in a new environment (Pickl, 2019). Those anticipating low adjustment costs may capitalize on policy and institutional responses to expand their market share at the sacrifice of rivals (Kennard, 2020; Vormedal and Skjærseth, 2020). They may even seek opportunistic search for regulatory benefits and competitive advantages (Vormedal et al., 2020). In the end, they become leaders or champions of transition.

In contrast, incumbent companies may stick to their core businesses and continue the production of their core products. They invest in more advanced technology in their core businesses, and to a minor extent, in emerging technologies. To attain new policy targets and comply with new regulations, they use pragmatic blending, appropriating the clean rhetoric traditionally associated with emerging technologies (Patala et al., 2019).

Incumbent companies may move back to weaker reorientation when the policy-making actors and structures themselves are subsumed in a deeper and wider "multiplex" of "deep incumbency" that transcends any particular socio-technical regime (Johnstone et al., 2017); a change in the government's framing of climate change and the main solution in a policy paper or plan is not sufficient to prevent them from moving back (Geels et al., 2016). They may also strategically camouflage actual opposition and support moderate regulation to offset the threat of more radical alternatives (Broockman, 2012). They would leave inefficient operation and insufficient operational capability intact if targeted policies at firm level are not implemented in a way that aligns executive incentives, strengthens internal oversight, and overhauls enduring cadre culture (Leutert, 2016).

2.2. Underlying factors

2.2.1. Firm-specific factors

External pressures and subsequent policy and institutional responses disproportionally impact each company. First, consequent damages are varied by the incumbent's characteristics, ability to respond, and structural power in relation to decision makers (Lockwood et al., 2019). Incumbents that depend on nuclear power and domestic markets are hit the hardest by market liberalization of the electricity market, an energy policy that guarantees renewable producers priority in feeding electricity into the grid, a nuclear phase-out policy, and the entry of the information and communication sector into smart grids (Heiskanen et al., 2018). These incumbents tend to be unveiled with business restructure, in case financially sound companies within the group find opportunities for synergies (Criqui and Zérah, 2015), or external financial institutions or investors find profit opportunities. Restrictive policies such as spatial planning and zoning can exert greater influence on companies' investment decisions than policies aimed at encouraging investment (Darmani et al., 2016).

Second, incumbent companies have different perceptions on external pressures and subsequent policy and institutional responses, and thus, their long-term corporate strategies. Some incumbents see them as incurring damages and decide to stay inert or move back to weak reorientation. Active delay in transition may increase their chances of survival, because they can buy themselves time to either adapt to the transition or prevent it altogether (van Mossel et al., 2018). They also see reconfiguring their core businesses as risky if it involves unrelated diversification, because of the difficulty in leveraging existing strategic assets and capturing scope benefits (Hartmann et al., 2020). Unless external pressures and subsequent institutional responses cause them to lose legitimacy and increase uncertainty about future business activities, these incumbent companies show less interest in investing in alternative businesses (Pickl, 2019).

By contrast, other incumbent companies perceive that addressing market needs and properties in new sectors increases the chance to earn profit or that moving into niches increases their chances of survival in comparison to remaining inert. They may perceive profit opportunities in research, development, and deployment for environmental and climate change purposes when they see government support (Harvey et al., 2018). This holds especially when such support is provided under stable and credible institutions, including consistent long-term demand-side policies, targets, legitimacy, and alignment with practices in other sectors and regional/local institutions (Negro et al., 2012; Reichardt and Rogge, 2016; Hansen and Coenen, 2017). They have greater motivation for innovation when market-based policies and performance-based regulations are implemented, which allow them wider discretion for technical choice than technology-based ones (Andersen and Sprenger, 2000; Lanoie et al., 2011). They may perceive positive feedback effect between manufacturers' innovation expenditures for alternative technologies and their wider adoption in some policy mixes (Rogge and Johnstone, 2017; Edmondson et al., 2019).

Third, incumbent companies are diverse in knowledge, prior experience, and organizational culture on sustainable practices (Hartmann et al., 2020). As companies gain experience, they develop capabilities that can be deployed across a range of strategic initiatives and activities. Incumbents with a history of innovative changes are more likely to take advantage of the opportunities (van Mossel et al., 2018), because their extension of existing competences can enhance the probability of new venture success (Pennings et al., 1994). Knowledge related to their ongoing businesses may enable them to transform their business in case it can provide insights and information for their transformation (Nilsen, 2017). Organizational cultures that prompt staff to volunteer for social, cultural, and environmental actions can also affect the speed and extent of transformation (Criqui and Zérah, 2015).

Finally, the companies' asset positions determine innovation opportunities (Teece et al., 1997). They are comprised of not only financial and managerial capabilities (Hansen and Coenen, 2017) but also technological, infrastructural, complementary, and reputational assets. Sufficient asset positions are required to support innovation and gain profits.

2.2.2. Socio-economic factors

Socio-economic factors shape the incumbent companies' strategies in several ways. First, incumbent companies have to listen to the

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voices of regional interests that are represented by municipal shareholders for historical reasons. Serious consideration of these voices makes it difficult for them to retain flexibility in reorienting and reorganizing their businesses and thus to make decisions on economic criteria (Kungl, 2015). The voices of regional interests can be stronger in countries that have both domestic coal mining and a vertically integrated electricity supply system (Rentier et al., 2019). This results in stronger institutional support for employment protection and higher coal subsidy policies, deterring incumbent companies from adapting to energy transition.

These challenges of changing regional identities can be better addressed if the phase-out policy is coupled with measures for managing structural change aimed at new, credible, and attractive economic perspectives for affected industries and regions and facilitating compromise (Leipprand and Flachsland, 2018). Measures improving infrastructure, education, research facilities, and soft location factors such as cultural and leisure time possibilities in a polycentric approach can further mitigate the damages and thus accelerate transitions (Oei et al., 2019).

Second, incumbent companies have to listen to the voices of customers with different social needs and preferences. Some society and customer segments are highly aware of the significance of climate issues and prefer more demand-oriented and environment-friendly service provision (Marvin and Guy, 1997), while others are characterized by massive irregular settlements that do not respect planning and building bylaws, unaffordability to pay the services, electricity thefts, and preference to access to basic services. Incumbent companies operating in the former segment have to be more responsive to societal norms and orientations (Darmani et al., 2016), which may accelerate a shift from fossil fuels to clean energy (Nilsen, 2017). Those operating in the latter segments are required additional investments in infrastructure and technologies (Criqui and Zérah, 2015), making business decisions that align with their global strategies difficult (Darmani et al., 2016).

2.2.3. *Institutional and policy factors*

The companies' actions and strategies are also affected by institutional and policy factors. Locked-in systems foster emergence of large networks of resource-rich companies that have a stake in system perpetuation and companies favored in political and institutional contests (Seto et al., 2016). These networks become self-reinforced and reinforce institutional lock-in in a stable regime, because they generate and enjoy mutual benefits among political, economic, bureaucratic, and social stakeholders within the network while disregarding benefits for outsiders including niche innovators with alternative technologies (Mori, 2019). These companies become path-dependent on a long-term national strategy, institutional support, and national control. They become reluctant to adapt to new environmental demands in time, because the existing system, such as a centralized electricity supply system, enables incumbent power companies to reduce the level of policy-induced disruption (Kattirtzi et al., 2021) and the amount of stranded assets.

Policy may generate two types of feedback effects that can create or augment prevailing political path-dependencies (Pierson, 2000) and carbon lock-in (Unruh, 2000). Technology feedback effects modify political costs of options (Jordan and Matt, 2014), and eventually change norms, policies, regulations and prevailing institutions (Verbong and Geels, 2021). By contrast, policy feedback effects distribute resources and create material incentives to create or strengthen particular social interest groups, transforming state capacities and institutions to affect later prospects for policy implementation (Pierson, 1993).

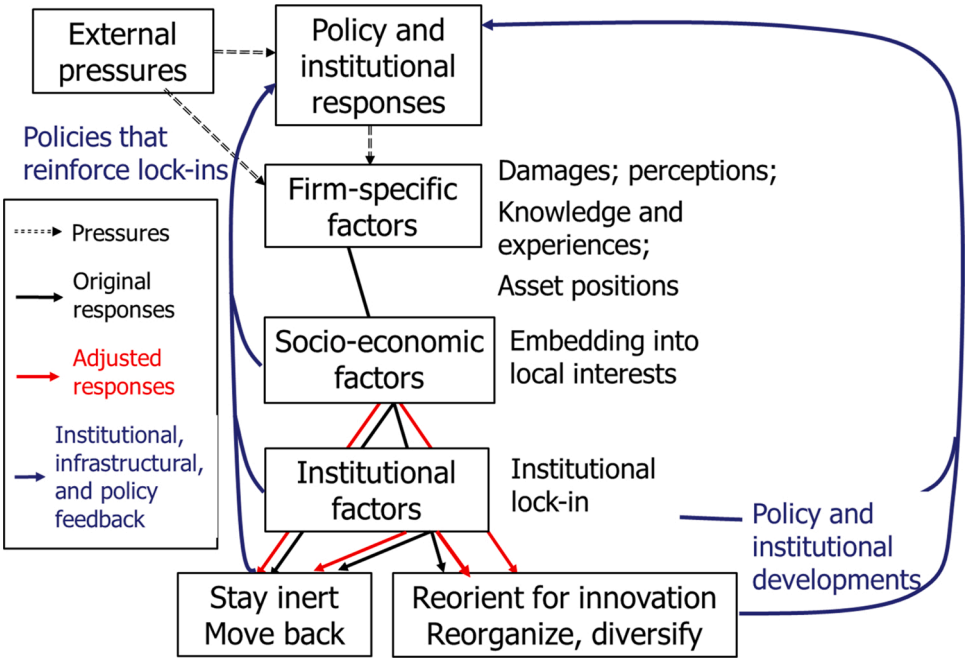

Fig. 1. Analytical framework for incumbent companies' heterogeneous responses and underlying factors.
Source: Author.

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2.3. Causal mechanism

Incumbent companies capitalize on historically accumulated capabilities—knowledge, prior experience, organizational culture, and asset positions—and competitive advantage to pursue multiple technological paths (Bergek and Onufrey, 2014). They initiate new market activities that can supplement their core activities in the short-term, and possibly sustain firm growth and survival in the long-term (Steen and Weaver, 2017). Their new and different initiatives generate heterogeneity within incumbent companies (Karltorp and Sandén, 2012). Some of them gradually step into strategic reorientation with exploration into new technologies and development of new capabilities, and strategic recreation that alters behavior, mindsets, and missions as external pressures and performance problems accumulate (Geels, 2014). Lead incumbent companies may provide resources to emerging suppliers and customer companies along their value chain to recombine and diversify their businesses (Steen and Weaver, 2017). They may make collective actions to build a favorable environment for their new technologies and capabilities, also widening heterogeneity (Planko et al., 2016). All of them increase heterogeneity between incumbent companies and industries.

A stock of historically accumulated capabilities, coupled with the socio-economic and institutional factors can also constrain future strategic options, directing incumbent companies to stay inert or move back to weaker reorientation. Limited perception of external pressures will direct them to act more defensively, protecting their market positions and corporate interests. Their technological changes tend to be incremental within the existing technological path. Over time, they become incapable of changing responses to reorientation and diversification not only through the reinforcing mechanisms but also by policy and institutional changes. The changes can destroy their competitive position for the benefit of development of the industry as a whole (Bohnsack et al., 2016).

Fig. 1 provides a schematic summary of the typologies of responses, underlying three factors, and causal mechanisms that generate heterogeneous responses of incumbent companies as an analytical framework. It suggests that heterogeneity can be expanded not only by self-reinforcing mechanisms but also technology and policy feedback effects that strengthen them, and incumbent companies' proactive and strategic choices to address accumulating external pressures and performance problems.

3. Methodology and case selection

3.1. Research design and case selection

We adopted a case-study strategy with an embedded single-case study design. A case study is more suitable to answer research questions that inquire into the "how" and "why" of things and that focus on contemporary, and not entirely historical phenomena (Yin, 2014). The single-case study design is justifiable, because the case represents a critical test of existing theory that has been built mostly on the basis of European cases. The embedded case study design is also justifiable, since our case study focuses on the incumbents' heterogeneous responses and is a representative of the global nature of the electricity supply system transition.

We employed an integrated analysis of business and financial performances of individual incumbent companies as an analytical methodology. Though resource constraints have been pointed out as a key determinant of the incumbents' responses to regime destabilization (van Mossel et al., 2018), few researchers have explicitly considered them in empirical analyses (Andersen and Gulbrandsen, 2020), let alone using financial performance data. Business and financial performances in incumbent companies' annual reports provide us rich evidence that explains how resource constraints work for heterogeneous responses. We conducted a comparative analysis of different types of incumbents to gain a deeper understanding of the effects of determinants on the incumbents' responses.

We examined five major state-owned power groups (the Big Five)—Huaneng, Guodian, Huadian, Datang, and State Power Investment Corporation Limited (SPIC)—and Shenhua and the China Resources Group (Huarun) as cases and identified them as major incumbent power generators. The selection logic is that, in 2013, the government mandatorily restricted these groups from investing only in either ultra-super critical (USC) plants with a capacity of more than 600 megawatts or supercritical (SC) fluidized bed plants with a capacity of more than 300 megawatts, and high efficient fuel gas desulfurization and denitrification equipment[1] . China's power generation has been dominated by coal and, to a lesser extent, hydropower, despite recent rapid growth in gas, wind, and solar power (Fig. 2). This coal-dominated energy structure has been a major source of serious air pollution and greenhouse gas emissions. The structure of Chinese electricity industry is not as concentrated as its oil and gas industry due to the 2002 power sector reform that vertically separated the State Power Corporation (SPC) into generation, transmission, and distribution; and horizontally separated generation into the Big Five. The Big Five collectively increased their market share by more than 10 percent between 2004 and 2011, supplying half of the total electricity production in 2011, competing with each other and with other central government-owned generators such as Shenhua, the China Three Gorges Corporation, and the China National Nuclear Corporation, provincial state-owned companies, joint-ventures, and state commercial generators such as Huarun (Fig. 3). Their dominance in electricity supply prompted the government to adapt the targeted regulations for the Big Five and the emerging coal power generators, Shenhua and Huarun.

In addition, each of the Big Five companies has different asset positions. Datang succeeded the assets of SPC's major businesses in the north and northwestern regions and established Datang Coal as a subsidiary dedicated to coal production in Inner Mongolia.

[1] National Development and Reform Commission, Ministry of Environmental Protection, and National Energy Administration (2014), Notification on the Action Plan for Upgrading and Transformation of the Energy Conservation and Emission Reduction of Coal-fired Power (2014–2020). It aimed to achieve the target of a heat rate lower than 300 gce/kWh for new coal power plants.

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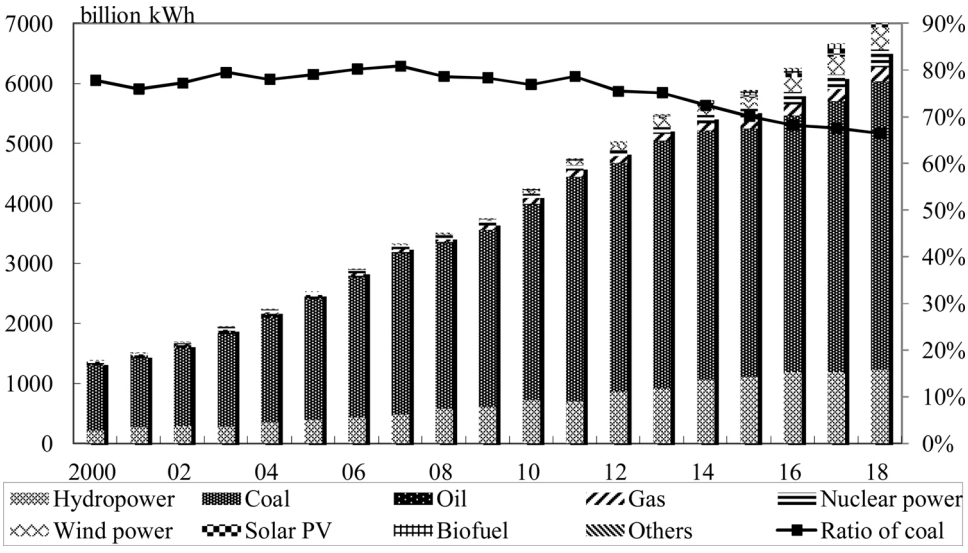

Fig. 2. Energy mix in power generation in China (2000–18).
Source: Compiled by the author, based on data from IEA (2020).

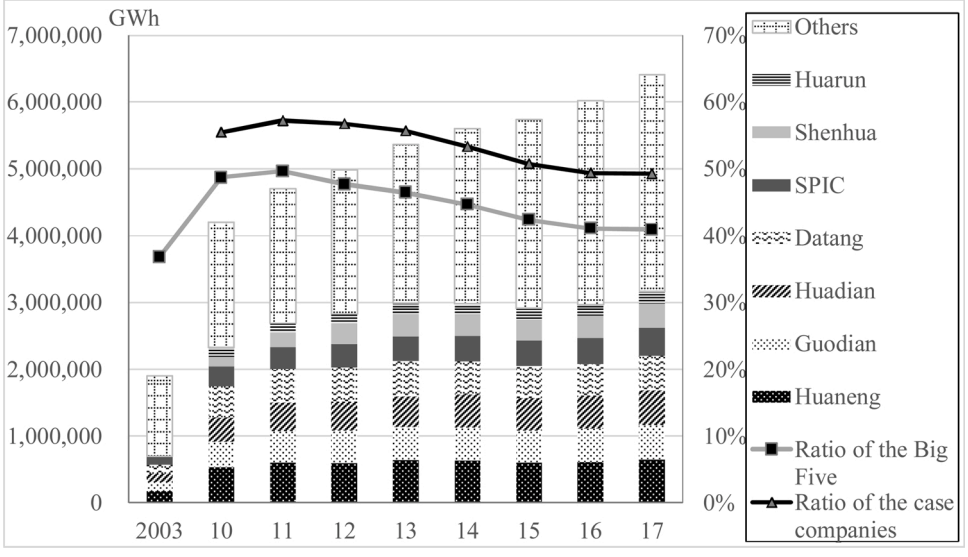

Fig. 3. Industrial structure by generated electricity (2003–17).
Source: Compiled by the author, based on data from the China Electric Power Yearbook Editorial Committee (2004, 2011, 2013, 2015, 2017, 2018).

Huaneng acquired the local-based listed generator of Inner Mongolian Meng Dian Thermal Power as a subsidiary, as well as a 49 percent share in the Huating Coal Group located in Gansu Province in 2008 and 2009. Datang and Huaneng joined the Shenhua-initiated dedicated rail projects in Inner Mongolia to build a comprehensive base with coordinated coal, power, and transportation. Guodian acquired a majority of the stakes in the Inner Mongolia Pingzhuang Energy Resources Group in 2008 (Inner Mongolia Pingzhuang Coal Industry (Group) Co. Ltd., n.a. (2021)) to secure stable coal supply. In contrast, Huadian's subsidiary, the Huadian Power International Corporation, acquired a minor stake in a number of coalmines[2] . SPIC did the same for the Mengdong Group Company and owns the Huolinge Coal Power Company, letting them prioritize supply of thermal coal for the groups' new mine-mouth coal power plants (Rui et al., 2015). SPIC, together with Datang, Guodian, and Huarun, invested in a rail project to transport their coal from Inner Mongolia to Liaoning and other provinces (Rui et al., 2015).

Shenhua was created as a state-owned enterprise (SOE) to promote integration of the coal and power business as a means of

[2] They include the Shanxi Shuozhou Wantongyuan Erpu Coal Mining Company and the Shanxi Dongyi Zhonghou Coal Industry Company.

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addressing the coal power conflict. It was assigned to develop coal power bases, with the grants of large, high-quality coalfields of Shenfu Dongshen, dozens of power plants from the State Planning Commission, and large soft loans from the Development Bank and the stock market (Andrew-Speed, 2012). Then, the company equipped itself with the latest modernized technologies to develop dedicated railways and ports, and to acquire coalmines, coalfields, or equity stakes in coal and power assets such as the Guohua Power.

Huarun originates from a Hong Kong-based trading company and has been restructured into a state-owned holding with several affiliates. The group has an expanding business, including consumer products, healthcare, energy services, urban construction and operation, and technology and finance, in Hong Kong and Mainland China (China Resources Holdings, 2019).

At first glance, it might seem odd to exclusively select state-owned power groups for comparison, since China is featured by a top-down and non-participatory approach to public policy making (Gilley, 2012). In addition, the Communist Party of China exercised power over personnel to appoint state-owned enterprise (SOE) leaders with better performances to higher positions in the country's political hierarchy, incentivizing them to comply with government priorities (Kong and Gallagher, 2017). Nonetheless, we expect heterogeneous responses among them, since the country is also featured by "national policies, local countermeasures": that is, exploiting the ambiguity of national laws and regulations to figure out ways around them (Ma and Ortolano, 2000), and the interactive experimentalist governance between central and local governments that ensures local experimentations under authoritarian control (Zhu and Zhao, 2018).

3.2. Data sources

For the case study, we adopted a mixed-method design that comprises qualitative content analysis and quantitative statistical analysis. To study the transition of the electricity supply system, we relied on holistic data collection strategies. We used data from secondary sources (academic books, articles) and primary sources such as business journals and daily newspapers. To study the incumbent companies, we derived data from annual financial reports of the corporate groups and their listed subsidiaries and from press reports issued by these groups. We collected documents from online archives by searching for the companies' names.

4. Results of the case study

4.1. External pressures, policy and institutional responses, and emerging niche innovations

In response to worsening air pollution and energy security requirements, the Chinese government implemented stringent mandatory reduction targets in its Five-year Plan (FYP) for sulfur dioxides since the 10th FYP (2001−05), energy intensity since the 11th FYP (2006−10), and carbon intensity since the 12th FYP (2011−15)[3] . On the other hand, the RMB four-trillion fiscal stimulus and subsequent investments in infrastructure and heavy industries caused severe power shortages and increased emissions. To satisfy these conflicting requirements, power generators invested in large-scale, more efficient, and low-emission coal power plants; and fuel-gas desulfurization and denitrification, set aside of increasing the operating hours of the existing coal power plants.

Nonetheless, these investments caused a thick cloud of smog spreading from Beijing and Tianjin to the Hebei Province and from the Yangtze River Delta to the Pearl River Delta. This raised health concerns and shook the legitimacy of the government (Ren and Shou, 2013).

In response, the government issued the Action Plan on Prevention and Control of Air Pollution in 2013. The Plan aims to accelerate the replacement of small-scale coal power plants, commercial boilers, industrial plants, and non-utility power-generation and district-heating plants with large and efficient ones. It also prohibited power generators from installing new coal plants in coastal regions and imposed a cap on the amount of primary energy consumption and coal consumption[4] . Subsequently, the government implemented the stringent technology-based mandate described in Section 3.1.

In addition, a long-standing concern about energy security and the framing of climate change as an issue of development (National Development and Reform Commission (NDRC, 2007) prompted the government to prioritize new energy and energy efficiency to safeguard energy security (Mori and Takehara, 2018). With this recognition, the government implemented the Renewable Energy Law, and in 2007 it mandated power generators to have renewable energy-sourced generation capacity more than 3 percent by 2010 and 8 percent by 2020. Then, it initiated a national concession program for renewable energy; implemented a feed-in tariff for offshore wind in 2009, solar photovoltaic (PV) in 2011, and nuclear power in 2013 (IESM, 2014); and mandated the state grid operators to prioritize them over coal (Fang et al., 2012). This industrial fostering policy succeeded not only in the emerging Chinese niche wind turbine and solar PV cell and module manufacturers but also in the Chinese wind and solar power generators. Installation of wind and solar power has outpaced the updated targets against the target set for the 12th FYP.

This achievement in wind and solar power brought about more ambitious mandatory targets to the ratio of coal in primary energy consumption and the generation capacity of wind and solar power in the 13th FYP (Gosens et al., 2017). In the 2016 congress session, the government announced an increase in natural gas power and coal power with USC technology as a means of reducing coal

[3] The reduction targets were 10 percent in the 11th FYP, 8 percent in the 12th FYP, and 15 percent in the 13th FYP for sulfur dioxides; 20 percent in the 11th FYP, 16 percent in the 12th FYP, and 15 percent in the 13th FYP for energy intensity; and by 17 percent in the 12th FYP and 18 percent in the 13th FYP for carbon intensity.

[4] State Council (2014), Energy Development Strategy Action Plan (2014−2020). The Plan also set the target on the share of coal by below 62 percent of primary energy consumption in 2020.

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dependence to less than 50 percent. Moreover, it implemented coal consumption standards for coal power plants with a capacity of more than 350 GW and directed inefficient coal plants to scrap 10 GW of their capacity (Climate Nexus, 2015). In 2017, the government forcefully stopped the construction of 79 thermal power plants nationwide and did not allow them to start constructions in the subsequent year (Inner Mongolia Meng Dian, 2018: 24).

The government also accelerated the reform of SOEs. In 2015, it released the Guiding Opinions of the Communist Party of China Central Committee and the State Council on Deepening the Reform of State-Owned Enterprises, which required further consolidation of their assets, the development of mixed ownership, and the loosening of state authority over executive management. At the People's Congress session in 2017, the prime minister also announced plans to accelerate the consolidation of SOEs to reduce excess production capacity.

4.2. Responses of major incumbent power generators

Major incumbent power generators adopted homogeneous responses to the 2007 mandate on renewable energy targets. They established a dedicated subsidiary for renewable energy-sourced generation within a group (Table 1) and located wind power in the Inner Mongolia Autonomous Region and the Gansu Province where wind resources were the richest and the leverage cost of wind power was the cheapest (Global Wind Electricity Council (GWEC, 2011). Their responses resulted in an increase in the ratio of non-hydro renewable energy, which accounted for more than 10 percent of their installation capacity (Fig. 4a) and five percent of the total generated amount by 2017 (Fig. 4b). The Big Five played a leading role in the wind power development (Li et al., 2014) and collectively accounted for more than half of the total wind power capacity put on the grid in the first half of the 2010s (Fig. 5).

By contrast, they adopted heterogeneous responses to the mandated coal-ratio targets and the technology-based regulations to install USC and SC. Huadian and SPIC increased the largest installation capacity in 2013−17, approximately by 35 GW each; followed by Huaneng by 30 GW; Guodian and Datang by approximately 22.5 GW; and Shenhua by 20 GW (Fig. 6). During this period, Huadian invested in natural gas power generation and hydropower (China Huadian Group Corporation, 2019), and SPIC has shifted to solar PV and nuclear power (Fig. 4a), becoming the largest solar PV generator among the major incumbent power generators. Huaneng invested in large-scale SC coal plants to consolidate small coal power plants and acquired local generators to simultaneously expand its market share. Datang shifted investments to wind power and hydropower, and Guodian developed more efficient fuel-gas sulfurization and denitrification technologies for large-scale coal power plants, scrapped small coal power plants, and developed and invested in wind power. Although Huarun increased the installation capacity by 6 GW in the same period, the company has reduced it since 2015.

They also adopted heterogeneous diversification strategies. Huaneng and Datang also established subsidiaries for coal chemical products to diversify their coal business, and Datang and Huadian established subsidiaries for financial asset management to diversify their businesses into non-coal businesses.

4.3. Factors behind the heterogeneous responses

4.3.1. Firm-specific factors

The incumbent companies' diverse asset positions generated their heterogeneous responses. Incumbent companies with sufficient technological capabilities to develop USC, SC, and fuel-gas desulfurization and denitrification stayed inert to develop them and aggressively replaced high-emission coal power plants with low-emission ones (China Electric Power Yearbook Editorial Committee, 2018; Huaneng Power International, 2011, 2020). Conversely, those that had fostered subsidiaries or those with technological capabilities to develop offshore wind and solar accelerated their development and deployment by themselves and acquired independent renewable energy-sourced power generators to do so (China Guodian Power Development Corporation, 2012). The shift in the energy mix enabled them to decide on scraping and stopping new investments in heating plants and replacing them with large-scale combined heat and power and offshore wind.

Major incumbent power generators that had gained sufficient financial capital by the decline in coal prices, the tail-raising effect of on-grid tariffs adjustments, and rising electricity demand by the RMB four-trillion fiscal stimulus and subsequent investments in the first half of the 2010s stayed inert to reinforce coal power integration, regaining operational profit (Table 2). They capitalized on their financial capabilities to invest in large-scale coal power plants, reinforcing lock-in into coal-based power generation to gain larger influence on the domestic market and policy (Rui, 2015). They also acquired and merged with independent power generation companies to cover all the provinces. By contrast, those that capitalized on subsidiaries to invest in developing coal chemical and solar PV faced a stagnant sales performance (Chen, 2016), causing deficit for the group's companies. Some were unveiled by mergers with other incumbent generators that had earned from vertically integrated coal power businesses and kept their market share (China Guodian Power Development Corporation, 2018). Others became incapable of investing to enhance their competitive edge (China Datang Group Corporation, 2018), thus losing their market share and reducing the amount of power generation (Fig. 3).

Major incumbent power generators that perceived profit opportunities but lacked sufficient technology and capabilities for innovation decided to incorporate natural gas, nuclear, and renewable energy-sourced power generation, as well as financial asset management, into their business portfolios. Some took advantage of their knowledge and past experiences of downstream gas distribution (China Resources Holdings, 2019; Huadian Power International Corporation, 2020) to operate these plants by themselves. Others completely merged with dedicated renewable energy companies (Huaneng Power International, 2019) or acquired minor stakes of dedicated generators (State Power Investment Corporation (SPIC), 2018), keeping the existing coal-based installations operational and initiating new and renewable energy-based ones.

Table 1
Structure of the Major Incumbent Power Generators Groups, as of 2017.

Type of companies	China Huaneng Group	China Guodian Group	China Shenhua Energy	China Huadian Group	China Datang Group	State Power Investment Corporation	Huarun/ China Resources Holdings
Core listed power generation corporation	Huaneng Power International	Guodian Power Development Corporation	Guohua Electric Power	Huadian Power International	Datang International Power	China Power International Development	CR Power Holdings
Coalmining subsidiaries	Huating Coal Group (Gansu)	Inner Mongolia PingZhuang Energy Resources	–	Shanxi Shuozhou Wantongyuan Erpu; Shanxi Dongyi Zhonghou [unlisted]	Datang Coal	Mengdong Group Company; Huolinge Coal Power Company	–
Renewable energy listed subsidiary 1	Huaneng Renewables	China Longyuan Power	Guohua Energy Investment	Huadian Fuxin Energy	Datang Renewable Power	Shanghai Electric Power	–
Renewable energy listed subsidiary 2	Lancang River Hydropower	–	–	–	Datang Huayin Electric Power	China Power New Energy Development	–
Local-based listed subsidiaries	Inner Mongolia Meng Dian Thermal Power	Changyuan Electric Power	–	Huadian Energy Company; Shenyang Jinshan Energy; Guizhou QianYuan Power	Guangxi Guiguan Electric Power	–	–

Source: Compiled by the author, based on data from China Electric Power Yearbook Editorial Committee (2018) and Rui et al. (2015).

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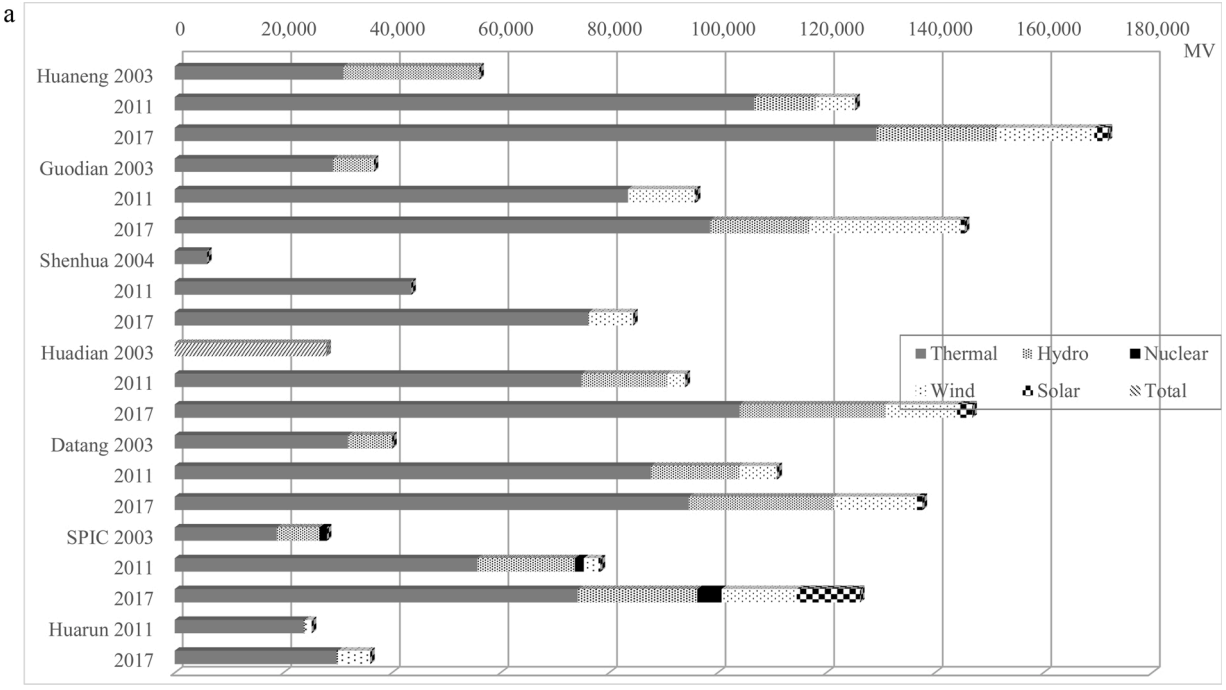

Fig. 4a. Installed capacity of major incumbent power generators in China by energy mix, 2003, 2011, and 2017.
Note: Shenhua makes annual installation capacity data available since in 2004.
Source: Compiled by the author, based on data from the Editorial Board of the China Electric Power Yearbook Editorial Committee, 2004, 2012, 2018), China Shenhua Energy Company (2006), and China Guodian Power Development Corporation (2019).

4.3.2. Socio-economic factors

The companies' responses were also affected by how the consolidation and coal power integration policies mitigated a cultural gap between the coal and power sectors, and ultimately the coal power conflict, and created technological lock-ins at each company. The power sector is characterized by high concentration, close ties with the central government, and a technocratic approach to management in a less competitive environment, whereas the coal sector is fragmented, has close connections with the local governments, and uses less advanced technology to compete within a market framework (Rui et al., 2015). Major incumbent power generators attempted to overcome the gap by enhancing economic ties, and building an integrated business model for coal, power, and transportation to a varied extent.

Those that established strong ties spent the "excess" operational profit gained by stagnant coal prices to invest in large-scale USC and SC technologies at their local power generation subsidiaries that relied on local coal mining (Inner Mongolia Meng Dian, 2020). They also used the "excess" operational profit to increase their stakes in the acquired coal mining and local power generation subsidiaries[5] (Huadian Power International Corporation, 2016).

Strong ties between their local power generation subsidiaries and local coal mining companies protected their vested interests at the sacrifice of blocking major incumbent power generators from investing in wind power as a means of achieving the mandated renewable energy targets. When faced with the emergence of wind and solar power, they jointly worked on provincial governments and grids to resist policies that foster wind power and reduce coal use, to protect their revenues and employment from local incumbent coal power generators and coalmines (Mori, 2018). This institutional work resulted in severe wind and solar curtailment in the Northeast and Northwest regions, and the government ordered the wind farms to shut down and directed them to buy production quota from local coal power generators (Yang, 2017).

In contrast, major incumbent power generators that had weak ties took advantage of the lifting of the coal import ban and the development of gas pipelines to locate coal, gas, and wind power in the East and Southern coastal regions. The major incumbent power generators' shifts toward alternative energy sources generated a feedback effect, unlocking coal-centered power generation and ties with local interests.

The major incumbent power generators' embedding into local interests was further weakened by the central government's Plan for Classified Disposal of Coal Mines that aimed to close small coal mining productions of less than 300,000 tons per year by 2021. Under the Plan, the government scheduled to cut 290 million tons of cumulative coal capacity, or 60 percent of the overcapacity in 2016 (Shi

[5] Huadian adopted the strategy to acquire local power generation companies to increase the installation capacity since its establishment (Rui et al., 2015).

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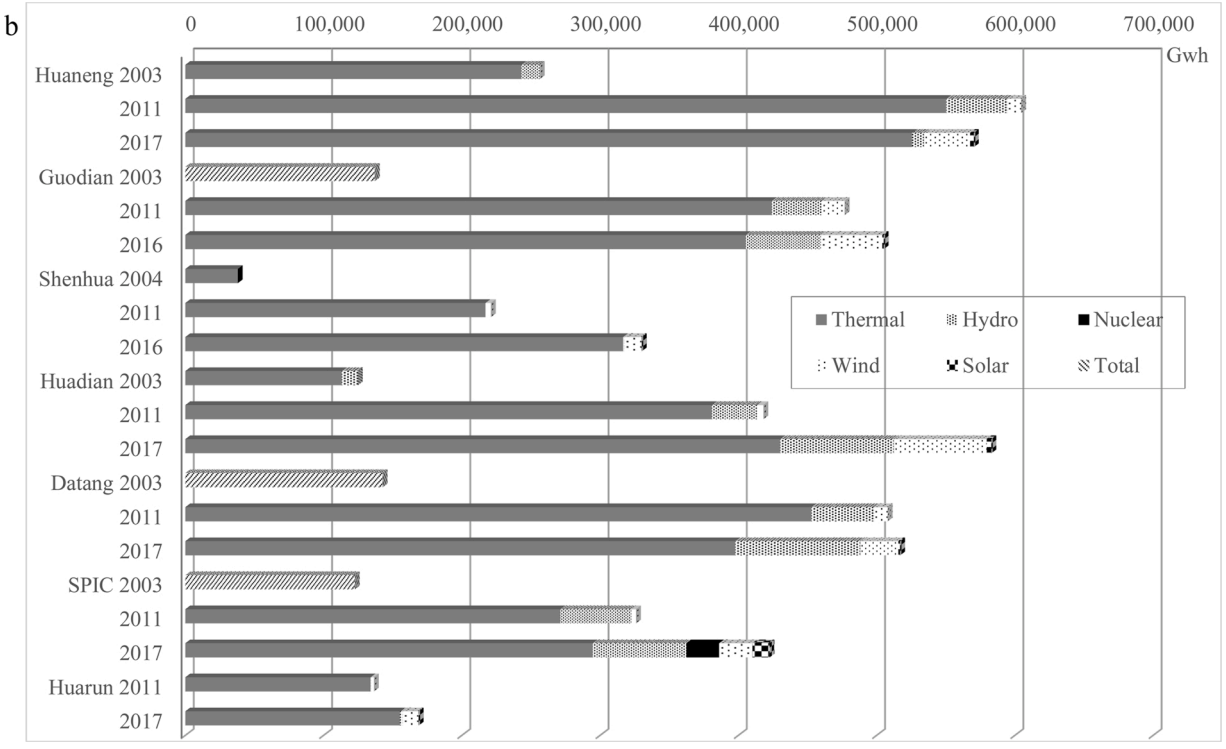

Fig. 4b. Generated electricity by major incumbent power generators in China by energy mix, 2003, 2011, and 2017.
Note: We use the generation data in 2016 for Guodian and Shenhua since their merger rendered individual data inaccessible.
Source: Compiled by the author, compilation based on data from the on China Electric Power Yearbook Editorial Committee (2004, 2012, 2017, 2018), China Shenhua Energy Company (2006), and China Guodian Power Development Corporation (2019).

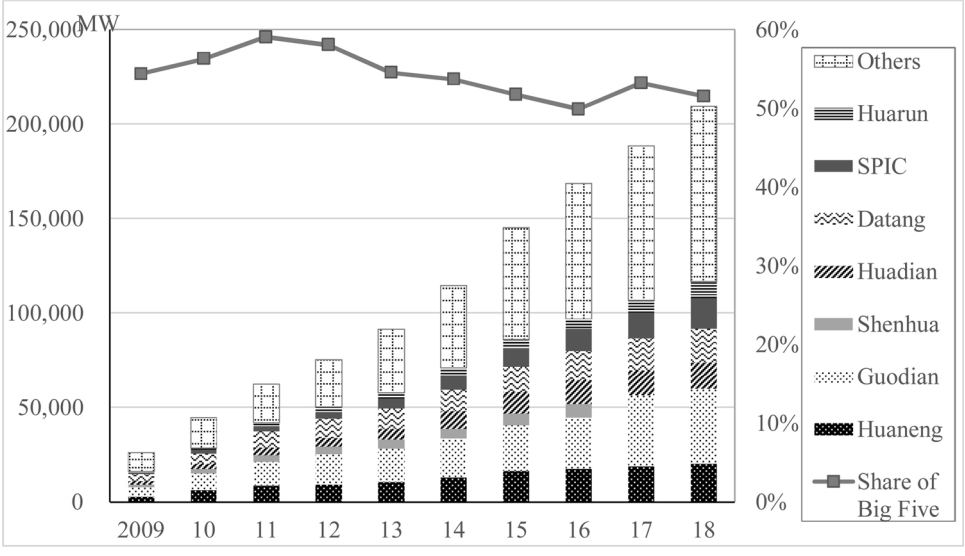

Fig. 5. Cumulative wind power installation capacity by power generators (2009–18).
Note: Guodian's capacity in 2017–18 are sum of Guadian and Guohua, a power generation subsidiary of Shenhua.
Source: Compiled by the author, based on data from the China Wind Energy Association (2016, 2017, 2018, 2019), IEA Wind (2011, 2013, 2015), and Li et al. (2010, 2012, 2014).

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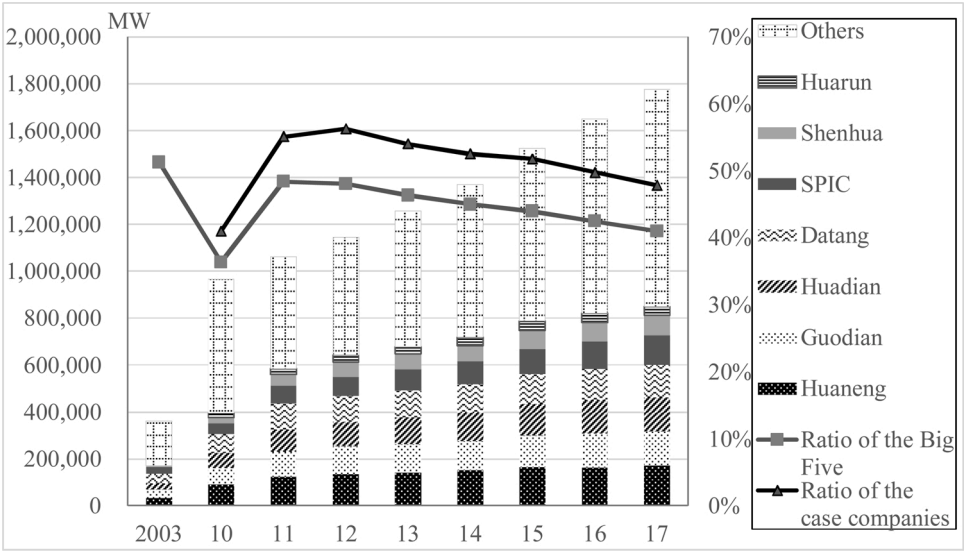

Fig. 6. Installation capacity of power generation in China by generators (2003–17).
Source: Same as Fig. 3.

Table 2
Financial performances of major incumbent power generators in 2011 and 2017.

	Total Asset		Total Equity		Turnover		Turnover of power and heating		Profit before income tax		Operational profit of power and heating		CNY billion Net Profit	
	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017
Huaneng	751.3	1,039.6	112.9	219.6	270.3	260.7	219.6	211.8	6.1	11.9	0.2	9.1	2.0	6.9
Guodian	663.4	805.0	108.9	153.0	214.3	192.6	149.9	152.7	6.1	8.1	−0.9	8.7	3.2	0.8
Shenhua	635.1	567.1	391.5	374.6	282.0	248.7	67.6	79.2	75.0	57.1	9.2	9.8	69.6	7.4
Huadian	522.8	796.8	69.2	153.7	170.5	200.1	134.7	165.8	2.2	6.7	−4.6	36.3	0.5	4.8
Datang	616.1	720.8	75.5	144.5	187.2	171.0	159.5	157.2	1.6	6.5	−5.8	5.8	0.3	5.0
SPIC	503.4	1,001.2	70.8	62.1	157.6	200.9	98.3	31.2	2.6	9.4	−3.4	12.9	−0.6	1.3
Huarun	136.5	1,215.9	49.9	347.9	50.4	555.5	42.2	29.2	3.0	64.9	3.7	2.2	3.7	38.5

Source: Compiled by the author, based on data from China Electric Power Yearbook Editorial Committee (2012); China Huaneng Group Corporation (2018); China Guodian Group Corporation (2018); China Shenhua Energy Company (2018); China Huadian Group Corporation (2018; 2019), China Datang Group Corporation (2018); State Power Investment Corporation (SPIC) (2019), and China Resources Holdings (2019).

and Gillespie, 2020). By minimizing the influence of local interests on major incumbent power generators, the Plan helped major incumbent power generators to replace small and obsolete coal power and district-heating plants and thus make strategic decisions on economic logic (China Guodian Power Development Corporation, 2014, 2015, 2018), enter a legal bankruptcy process (Xu and Patton, 2019), and sell their local coal assets and local coal power plants to local companies that had stronger local interests (China Resources Holdings, 2019). In practice, however, the restructuring process was slow due to difficulties in guaranteeing re-employment for the estimated loss of jobs for 1.3 million coal sector workers (Yao and Meng, 2016) and lack of companies' funding. The coal price hike in response to the growing demand in 2016 gave an excuse to delay the restructuring of the coal industry.

4.3.3. Institutional factors

Major incumbent power generators collectively and individually lobbied the central and local governments (Kahrl and Wang, 2015) to reinforce institutional lock-in in the coal-centered electricity supply system and protect their vested interests from policies that restrict coal use. They lobbied to get approval for both coal and power projects (Liu et al., 2013). To get both approval and sustained support, they compromised by replacing coal power project proposals with combined heat and power and co-generation with USC technology (Roberts, 2017), especially in the Northeast regions where the regional heating system is indispensable to survive the cold winter, and in Guangdong where consolidation of small and obsolete coal power plants were required to meet both the increasing demand and the energy and carbon intensity targets (Mori and Liao, 2018). Through the coal association, they also organized and lobbied hard against plans to restrict imports (Wong and Sonail, 2014), getting coal power exemption from the 2014 coal ban.

Major incumbent power generators adopted heterogeneous responses to wind power curtailment caused by a lack of ultra-high voltage, direct current (UHV-DC) transmission lines. The curtailment caused substantially disproportional damages among major incumbent power generators. It severely hit major incumbent power generators that invested in wind power in Inner Mongolia to

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achieve the 2007 renewable energy mandate. They faced a comprehensive curtailment ratio of more than 19 percent in 2011, 2015 and 2016, which forced the group to restrict its wind power operations to less than 1,800 h (China Datang Corporation Renewable Power, 2015: 15). Thus, their wind power business fell into deficit. Some of them stayed at Inner Mongolia and converted their investments to hydropower projects, while others relocated to investment sites of hydropower projects in Yunnan Province (Huaneng Renewable Corporation, 2013, 2016; Huaneng Lancang River Hydropower, 2018) or acquired hydropower projects in water resource-rich Hubei Province to satisfy the government's mandatory renewable targets. Most of them shifted sites for wind power to regions with less curtailment or offshore wind, and postponed construction until the long-distance UHV-DC transmission lines were completed to connect wind power parks in Inner Mongolia and the Northwest regions to coastal regions with high consumption[6] (Huadian Power International Corporation, 2020). Those with sufficient financial capabilities continued to invest in wind power in Inner Mongolia by constructing their own transmission lines (Inner Mongolia Meng Dian, 2018).

The SOE reform also generated heterogeneous responses. The forced merger with the State Nuclear Power Technology Corporation (Shi and Gillespie, 2020) promoted SPIC to set the goal to be the world-class clean energy enterprise with global competitiveness by 2035 (State Power Investment Corporation (SPIC, 2019), and declaring a phase-out of coal power (China Asia Environmental New Energy, 2019). To achieve these targets, the incumbent power generator accelerated investments toward nuclear and renewable energy-sourced power generation.

5. Discussion

Fig. 7 provides a generalized analytical framework for causal mechanisms between heterogeneous responses, the underlying three factors, and sustainability transitions based on the findings of the above empirical case study. As in the Fig. 1, disproportional costs imposed by external pressures, coupled with subsequent policy goals without concrete policy instruments, and different perceptions of the demand for their core and new products generated heterogeneous responses within major incumbent companies. Some leverage their historically accumulated capabilities to reorient for innovation or diversify their business for their survival and expansion of market shares. Others stayed inert or moved back to the core business to protect their market position there and defend strong ties with their social and political stakeholders, reinforcing the lock-in.

The empirical case study elucidate how resultant companies' financial performances affect heterogeneous responses later on. Reorientation for innovation, reorganization and diversification bring profits only if they meet new market needs and generate synergies between existing and new businesses. Socio-economic factors such as embeddedness in local interests, and institutional factors such as whether access to institutions and infrastructures also affect financial performance. The core business may continue to bring higher market share and profit to incumbent companies than new business until new business, technologies and products are supported by development of complementarities in institutions, infrastructure, and organizational elements (Markard and Hoffmann, 2016; Mori, 2020). Perceived higher market share and profitability of the core business dampens incumbent companies from leveraging profits to reorient or diversify their business.

The empirical case study also elucidates how infrastructure developments affect financial performance of reorientation, diversification, and reorganization, and thus heterogeneous responses. The initial lack of UHV-DC transmission lines and economic dispatch rule caused severe wind curtailment, blocking incumbent power generators from diversifying their business into wind power. Coupled with recovered profitability of their core business, it directed many of them to move back to investing in their core business of coal and hydro power development. It was not until UHV-DC transmission lines became operational and economic dispatch was institutionalized that they resumed diversification into wind and added solar power as a business strategy to expand the market share under the increasing ambitious renewable energy targets.

This relationship between the heterogeneous responses of major incumbent power generators and the underlying factors, and the interaction between them can be interpreted as an extension of selective recognition, a pattern of interactive, experimentalist governance of the relations between the government and incumbent companies. Selective recognition is characterized by the local governments' policy innovations according to national goals and local preferences without concrete policy designs and instruments, and the central government's review, uptake, and recentralization in the end. Heterogeneous responses within local governments are evaluated as opportunities for the central government to learn the effectiveness of alternative or innovative policy instruments to gain legitimacy (Wu et al., 2021; Uhde and Malima, 2020). Although the relations between the government and incumbent companies are not identical to the central–local government relations, heterogeneous responses within incumbent companies can play the same function, helping transform state capacities and institutions to affect later prospects for policy implementation.

Nonetheless, their heterogeneous responses have not generated such fierce conflicts of interests as to disband coalitions between incumbent power generators, and between incumbent power generators and grid companies. Despite the country's climate pledges, State Grid Corporation and the industrial association of the China Electricity Council collectively lobbied the government, succeeding in relaxing building regulations in an increasing number of provinces in 2001−23 (Myllyvirta et al., 2020).

The success of lobbying implies that heterogeneous responses can accelerate sustainable transitions only when they generate *several rounds of* policy feedback effects that induce co-evolution of socio-economic and institutional factors, and reduce those effects that reinforce social embedding and institutional lock-ins (Fig. 7). The co-evolution will give the government legitimacy to enhance state

[6] It was not until in 2017 that the three UHV-DC transmission lines started operation and enabled the transmission of wind power from Inner Mongolia to the Eastern region (State Grid Corporation of China, 2018a, 2018b). The operation of the Jiuquan-Hunan transmission line in 2017 also helped overcome wind curtailment.

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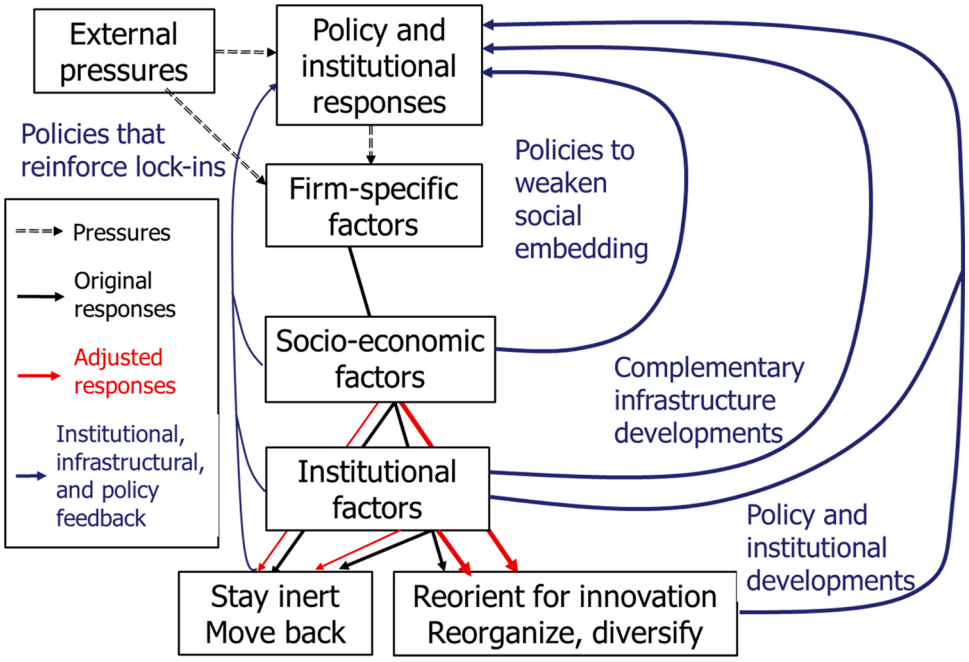

Fig. 7. Extended framework for incumbent companies' heterogeneous responses and underlying factors.
Source: Author.

capabilities for system transformation at the cost of those staying inert and moving back to weaker reorientation if it supports visibly higher and stable profits to new business, reduces the social and institutional costs of the shift to new business, and helps alter mindset and mission of leading incumbent companies and the government in the short-term.

6. Conclusions

Transitions research has frequently carried an unintentional bias for novelty and assumes incumbents as homogeneous groups that are "locked-in" to certain socio-technical regimes. In reality, incumbents are heterogeneous at the company and industrial levels and thus have heterogeneous responses to external pressures and subsequent policy and institutional responses.

Against this backdrop, we investigated the factors that contribute to the incumbent companies' heterogeneous responses, and their implications to sustainability transitions by building an analytical framework and conducting an empirical case study.

Our findings are summarized as follows.

First, incumbent companies are more likely to generate heterogeneous responses if firm-specific, socio-economic, and institutional factors give different opportunities and barriers. Policy feedback effects and development of complementarities in infrastructure, instruments, and organizational elements can increase heterogeneous responses.

Second, incumbent companies' heterogeneous responses can destabilize regime and give legitimacy for alternative or innovative policy instruments and infrastructure and institutional development, but requires co-evolution with socio-economic and institutional factors to accelerate sustainability transitions.

These findings indicate the need for further research on this topic. Though our empirical case study shows that mergers and acquisitions can be effective measures to change corporate strategies from resistance to adaptation, China can make it due to both the larger potential among domestic companies and the state control of incumbent companies. The question of how to finance complementary investments, advance institutional reforms, and gain social acceptance over scrapping overcapacity at the expense of massive job loss in a democratic manner has to be explored further. Increasing reliance on the international market (State Power Investment Corporation (SPIC, 2018; Mori and Horii, 2020) may create differences in the companies' responses and thus in the directions of change and speeds of transition. Future research should investigate how influential the identified determinants are in specific contexts across countries.

Declaration of Competing Interest

The authors report no declarations of interest.

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References

Andersen, A.D., Gulbrandsen, M., 2020. The innovation and industry dynamics of technology phase-out in sustainability transitions: insights from diversifying petroleum technology suppliers in Norway. Energy Res. Soc. Sci. 64, 101447. https://doi.org/10.1016/j.erss.2020.101447.
Andersen, M.S., Sprenger, R.U. (Eds.), 2000. Market-Based Instruments for Environmental Management: Politics and Institutions. Edward Elgar, Cheltenham.
Andrew-Speed, P., 2012. The Governance of Energy in China: Transition to a Low-Carbon Economy. Palgrave MacMillan, New York.
Bergek, A., Onufrey, K., 2014. Is one path enough? Multiple paths and path interaction as an extension of path dependency theory. Ind. Corp. Change 23, 1261–1297. https://doi.org/10.1093/icc/dtt040.
Berggren, C., Magnusson, T., Sushandoyo, D., 2015. Transition pathways revisited: established firms as multi-level actors in the heavy vehicle industry. Res. Policy 44, 1017–1028. https://doi.org/10.1016/j.respol.2014.
Bohnsack, R., Pinkse, J., Waelpoel, A., 2016. The institutional evolution process of the global solarindustry: the role of public and private actors in creatinginstitutional shifts. Environ. Innov. Soc. Transit. 20, 16–32. https://doi.org/10.1016/j.eist.2015.10.006.
Bosman, R., Loorbach, D., Frantzeskaki, N., Pistorius, T., 2014. Discursive regime dynamics in the Dutch energy transition. Environ. Innov. Soc. Transit. 13, 45–59. https://doi.org/10.1016/j.eist.2014.07.003.
Broockman, D., 2012. The problem of preferences: medicare and business support for the welfare state. Stud. Am. Political Dev. 26 (2), 83–106. https://doi.org/10.1017/S0898588X12000077.
Chen, 2016. 国电关闭光伏生产线 损失约40亿 (Guodian Closed Solar Photovoltaics Production Line, Lost RMB 4 Billion), 北极星太阳能光伏网讯 (22 December 2015) [accessed 30 June 2020] (in Chinese). http://guangfu.bjx.com.cn/news/20151222/693993.shtml/.
China Asia Environmental New Energy, 2019. State Power Investment Group Declares Complete Phase-out From Coal Business, and New Energy Becomes the Center in Investments in the Future (13 March 2019), https://www.sohu.com/a/301112390_100015980 [accessed 15 June 2020] (in Chinese)..
China Datang Corporation Renewable Power, 2015. Annual Report [accessed 22 May 2020] (in Chinese). 2015. http://www.hkexnews.hk/listedco/listconews/SEHK/2016/0429/LTN201604292030.pdf.
China Datang Group Corporation, 2018. 2017 Annual Report [accessed 22 May 2020] (in Chinese). https://www.shclearing.com/xxpl/cwbg/nb/201804/t20180428_375989.html.
China Electric Power Yearbook Editorial Committee, 2004. 2003 China Electric Power Yearbook. China Electric Power Press, Beijing (in Chinese).
China Electric Power Yearbook Editorial Committee, 2011. 2010 China Electric Power Yearbook. China Electric Power Press, Beijing (in Chinese).
China Electric Power Yearbook Editorial Committee, 2012. 2011 China Electric Power Yearbook. China Electric Power Press, Beijing (in Chinese).
China Electric Power Yearbook Editorial Committee, 2013. 2012 China Electric Power Yearbook. China Electric Power Press, Beijing (in Chinese).
China Electric Power Yearbook Editorial Committee, 2015. 2014 China Electric Power Yearbook. China Electric Power Press, Beijing (in Chinese).
China Electric Power Yearbook Editorial Committee, 2017. 2016 China Electric Power Yearbook. China Electric Power Press, Beijing (in Chinese).
China Electric Power Yearbook Editorial Committee, 2018. 2017 China Electric Power Yearbook. China Electric Power Press, Beijing (in Chinese).
China Guodian Group Corporation, 2018. 2017 Annual Report [accessed 24 June 2020] (in Chinese). https://www.shclearing.com/xxpl/cwbg/nb/201804/t20180428_375576.html.
China Guodian Power Development Corporation, 2012. 2011 Annual Report [accessed 4 June 2020] (in Chinese). http://pdf.dfcfw.com/pdf/H2_AN201203300005093903_1.pdf/.
China Guodian Power Development Corporation, 2014. 2013 Annual Report [accessed 4 June 2020] (in Chinese). http://file.finance.sina.com.cn/211.154.219.97:9494/MRGG/CNSESH_STOCK/2014/2014-3/2014-03-25/1327279.PDF/.
China Guodian Power Development Corporation, 2015. 2014 Annual Report [accessed 4 June 2020] (in Chinese). http://static.cninfo.com.cn/finalpage/2015-03-31/1200769853.PDF/.
China Guodian Power Development Corporation, 2018. 2017 Annual Report [accessed 4 June 2020] (in Chinese). http://pdf.dfcfw.com/pdf/H2_AN201805111141857270_1.pdf/.
China Guodian Power Development Corporation, 2019. 2018 Annual Report [accessed 4 June 2020] (in Chinese). https://pdf.dfcfw.com/pdf/H2_AN201904151319399498_1.pdf/.
China Huadian Group Corporation, 2018. 2017 Annual Report [accessed 24 June 2020] (in Chinese). http://ncds.shclearing.com/xxpl/cwbg/nb/201804/t20180427_373106.html/.
China Huadian Group Corporation, 2019. 2017 Sustainability Report [accessed 24 June 2020] (in Chinese). http://www.chd.com.cn/webfront/webpage/web/contentList/channelId/f445b265d3e840558df35178a3e8ef96/pageNo/1/.
China Huaneng Group Corporation, 2018. 2017 Annual Report [accessed 24 June 2020] (in Chinese). https://www.shclearing.com/xxpl/cwbg/nb/201804/t20180427_374264.html/.
China Resources Holdings, 2019. Social Responsibility Report 2018 [accessed on 22 May 2020]. http://www.crc.com.cn/responsibility/report/groupreport/201906/P020190630696196409032.pdf/.
China Shenhua Energy Company, 2006. 2005 Annual Report [accessed 22 June 2020] (in Chinese). http://www.shenhuachina.com/shenhuaChina/1382682910387/dqbg.shtml/.
China Shenhua Energy Company, 2018. 2017 Annual Report [accessed 19 May 2020] (in Chinese). http://www.shenhuachina.com/zgshww/2017/201803/47c8b086e3b644ecb9e881ab3fe27bf7/files/59dd1d31ade948eaba79c334a149eeaa.pdf/.
Chinese Wind Energy Association, 2016. Statistics on Wind Power Generation Capacity in China 2015 [accessed on 2 May 2020]. http://www.cwea.org.cn/industry_data_2015.html.
Chinese Wind Energy Association, 2017. Statistics on Wind Power Generation Capacity in China 2016 [accessed on 2 May 2020]. http://www.cwea.org.cn/industry_data_2016.html.
Chinese Wind Energy Association, 2018. Statistics on Wind Power Generation Capacity in China 2017 [accessed on 2 May 2020]. http://www.cwea.org.cn/industry_data_2017.html.
Chinese Wind Energy Association, 2019. Statistics on Wind Power Generation Capacity in China 2018 [accessed on 2 May 2020]. http://www.cwea.org.cn/industry_data_2018.html.
Climate Nexus, 2015. China's Climate and Energy Policy: Leadership Efforts on the Road to a Low-carbon Future [accessed 5 December 2016]. http://climatenexus.org/learn/international-actions/chinas-climate-and-energy-policy.
Criqui, L., Zérah, M.H., 2015. Lost in transition? Comparing strategies of electricity companies in Delhi. Energy Policy 78, 179–188. https://doi.org/10.1016/j.enpol.2014.11.007.
Darmani, A., Arvidsson, N., Hidalgo, A., 2016. Do the strategic decisions of multinational energy companies differ in divergent market contexts? An exploratory study. Energy Res. Soc. Sci. 11, 9–18. https://doi.org/10.1016/j.erss.2015.08.009.
Edmondson, D.L., Kern, F., Rogge, K.S., 2019. The co-evolution of policy mixes and sociotechnical systems: towards a conceptual framework of policy mix feedback in sustainability transitions. Res. Policy 48 (10), 103555. https://doi.org/10.1016/j.respol.2018.03.010.

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Fang, Y., Li, J., Wang, M., 2012. Development policy for non-grid-connected wind power in China: an analysis based on institutional change. Energy Policy 45, 350–358. https://doi.org/10.1016/j.enpol.2012.02.043.
Frei, F., Sinsel, S.R., Hanafy, A., Hoppmann, J., 2018. Leaders or laggards? The evolution of electric utilities' business portfolios during the energy transition. Energy Policy 120, 655–665. https://doi.org/10.1016/j.enpol.2018.04.043.
Fünfschilling, L., Truffer, B., 2014. The structuration of socio-technical regimes—conceptual foundations from institutional theory. Res. Policy 43, 772–791. https://doi.org/10.1016/j.respol.2013.10.010.
Geels, F.W., 2014. Reconceptualising the co-evolution of firms-in-industries and their environments: developing an inter-disciplinary Triple Embeddedness Framework. Res. Policy 43, 261–277. https://doi.org/10.1016/j.respol.2013.10.006.
Geels, F.W., Penna, C.C.R., 2015. Societal problems and industry reorientation: elaborating the Dialectic Issue LifeCycle (DILC) model and a case study of car safety in the USA (1900–1995). Res. Policy 41, 67–82. https://doi.org/10.1016/j.respol.2014.09.006.
Geels, F.W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., 2016. The enactment of socio-technical transition pathways: a reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990–2014). Res. Policy 45, 896–913. https://doi.org/10.1016/j.respol.2016.01.015.
Gilley, B., 2012. Authoritarian environmentalism and China's response to climate change. Environ. Politics 21 (2), 287–307. https://doi.org/10.1080/09644016.2012.651904.
Global Wind Electricity Council (GWEC), 2011. The Development of Wind Power Tariffs in China accessed 23 November 2020. http://probeinternational.org/library/wp-content/uploads/2011/10/LinkClick.aspx_.pdf/.
Gosens, J., Kåberger, T., Wang, Y., 2017. China's next renewable energy revolution: goals and mechanisms in the 13th five Year Plan for energy. Energy Sci. Engr. 5 (3), 141–155. https://doi.org/10.1002/ese3.161.
Hansen, T., Coenen, L., 2017. Unpacking resource mobilisation by incumbents for biorefineries: the role of micro-level factors for technological innovation system weaknesses, Technol. Anal. Strateg. Manag 29 (5), 500–513. https://doi.org/10.1080/09537325.2016.1249838.
Hartmann, J., Inkpen, A.C., Ramaswamy, K., 2020. Different shades of green: global oil and gas companies and renewable energy. J. Int. Bus. Stud. https://doi.org/10.1057/s41267-020-00326-w.
Harvey, H., Orvis, R., Rissman, J., O'Boyle, M., Busch, C., Aggarwal, S., 2018. Designing Climate Solutions: A Policy Guide for Low-Carbon Energy. Island Press, Washington DC.
Heiskanen, E., Apajalahti, E.-L., Matschoss, K., Lovio, R., 2018. Incumbent energy companies navigating energy transitions: Strategic action or bricolage? Environ. Innov. Soc. Transit. 28, 57–69. https://doi.org/10.1016/j.eist.2018.03.001.
Hess, D.J., 2014. Sustainability transitions. A political coalition perspective. Res. Policy 43 (2), 278–283. https://doi.org/10.1016/j.respol.2013.10.008.
Huadian Power International Corporation, 2016. 2015 Annual Report [accessed 4 July 2020] (in Chinese). http://vip.stock.finance.sina.com.cn/corp/view/vCB_AllBulletinDetail.php?stockid=600027&id=2271273/.
Huadian Power International Corporation, 2020. 2019 Annual Report [accessed 4 July 2020] (in Chinese). http://vip.stock.finance.sina.com.cn/corp/view/vCB_AllBulletinDetail.php?stockid=600027&id=5965753/.
Huaneng Lancang River Hydropower, 2018. Huaneng Lancang River Hydropower 2017 Annual Report [accessed 19 May 2020] (in Chinese). http://pdf.dfcfw.com/pdf/H2_AN201804251130078665_1.pdf,/.
Huaneng Power International, 2011. 2010 Annual Report [accessed 2 June 2020] (in Chinese). https://pdf.dfcfw.com/pdf/H2_AN201203020004786859_1.pdf/.
Huaneng Power International, 2019. 2018 Annual Report [accessed 2 June 2020] (in Chinese). https://vip.stock.finance.sina.com.cn/corp/view/vCB_AllBulletinDetail.php?stockid=600027&id=5121087/.
Huaneng Power International, 2020. 2019 Annual Report [accessed 2 June 2020] (in Chinese). http://static.sse.com.cn/disclosure/listedinfo/announcement/c/2020-04-01/600011_2019_n.pdf/.
Huaneng Renewable Corporation, 2013. 2012 Annual Report [accessed 19 May 2020] (in Chinese). http://www.hnr.com.cn/uploadfile/2013/0416/20130416061553586.pdf/.
Huaneng Renewable Corporation, 2016. 2015 Annual Report [accessed 19 May 2020] (in Chinese). http://www.hnr.com.cn/uploadfile/2016/0412/20160412080725845.pdf/.
IEA Wind, 2011. 2010 Annual Report [accessed 14 July 2020]. https://community.ieawind.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=822d2af3-4078-922e-5146-eec3a17cae6d&forceDialog=0/.
IEA Wind, 2013. 2012 Annual Report [accessed 14 July 2020]. https://community.ieawind.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=133ea3d2-bff1-8800-3dcf-a08f27f6fc55&forceDialog=0/.
IEA Wind, 2015. 2014 Annual Report [accessed 14 July 2020]. https://community.ieawind.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=43c441c4-9537-2091-056e-c242949461fd&forceDialog=133ea3d2-bff1-8800-3dcf-a08f27f6fc55&forceDialog=0/.
Inner Mongolia Meng Dian, 2018. Inner Mongolia Meng Dian Huaneng Annual Report 2017 [accessed 4 June 2020] (in Chinese). http://guba.eastmoney.com/list,600863,3,f.html/.
Inner Mongolia Meng Dian, 2020. Inner Mongolia Meng Dian Huaneng Annual Report 2020 [accessed 4 June 2020] (in Chinese). http://guba.eastmoney.com/list,600863,3,f.html/.
Inner Mongolia Pingzhuang Coal Industry (Group) Co. Ltd., n.a, 2021. Corporate Profile [accessed 14 November 2020] (in Chinese). http://pzmy.chnenergy.com.cn/pzmyww/gsjj/list04.shtml.
International Energy Agency (IEA), 2019. Status of Power System Transformation 2019: Power System Flexibility [accessed 4 July 2020]. https://www.iea.org/reports/status-of-power-system-transformation-2019/.
International Energy Agency (IEA), 2020. IEA Data and Statistics [accessed 26 September 2020]. https://www.iea.org/data-and-statistics/data-tables?country=CHINAREG&energy=Electricity&year=2019/.
Johnstone, P., Stirling, A., Sovacool, B., 2017. Policy mixes for incumbency: exploring the destructive recreation of renewable energy, shale gas 'fracking,' and nuclear power in the United Kingdom. Energy Res. Soc. Sci. 33, 147–162. https://doi.org/10.1016/j.erss.2017.09.005.
Jordan, A., Matt, E., 2014. Designing policies that intentionally stick: policy feedback in a changing climate. Policy Sci. 47 (3), 227–247. https://doi.org/10.1007/s11077-014-9201-x.
Kahrl, F., Wang, X., 2015. Integrating Renewable Energy Into Power Systems in China: a Technical Primer-electricity Planning. Regulatory Assistance Project [accessed 19 June 2017]. http://www.raponline.org/wp-content/uploads/2016/05/rap-e3-chinaelectricityplanning-2015-oct.pdf/.
Karltorp, K., Sandén, B.A., 2012. Explaining regime destabilisation in the pulp and paper industry. Environ. Innov. Soc. Transit. 2, 66–81.
Kattirtzi, M., Ketsopoulou, I., Watson, J., 2021. Incumbents in transition? The role of the 'Big six' energy companies in the UK. Energy Policy 148, 111927. https://doi.org/10.1016/j.enpol.2020.111927.
Kennard, A., 2020. The enemy of my enemy: when firms support climate regulation. Int. Organ. 74 (2), 187–221. https://doi.org/10.1017/S0020818320000107.
Kong, B., Gallagher, K.P., 2017. Globalizing Chinese energy finance: the role of policy banks. J. Contemp. China 26 (108), 834–851. https://doi.org/10.1080/10670564.2017.1337307.
Kungl, G., 2015. Stewards or sticklers for change? Incumbent energy providers and the politics of the German energy transition. Energy Res. Soc. Sci. 8, 13–23. https://doi.org/10.1016/j.erss.2015.04.009.
Kungl, G., Geels, F.W., 2018. Sequence and alignment of external pressures in industry destabilisation: understanding the downfall of incumbent utilities in the German energy transition (1998–2015). Environ. Innov. Soc. Transit. 26, 78–100. https://doi.org/10.1016/j.eist.2017.05.003.
Lanoie, P., Laurent-Lucchetti, J., Johnstone, N., Ambec, S., 2011. Environmental policy, innovation and performance: new insights on the Porter hypothesis. J. Econ. Manag. Strategy 20 (3), 803–842. https://doi.org/10.1111/j.1530-9134.2011.00301.x.
Lauber, V., Sarasini, S., 2015. The response of incumbent utilities to the challenge of renewable energy. In: Sandén, B. (Ed.), Systems Perspectives on Renewable Power. Chalmers, pp. 138–148. http://publications.lib.chalmers.se/records/fulltext/210536/local_210536.pdf.

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Lee, D., Hess, D.J., 2019. Incumbent resistance and the solar transition: changing opportunity structures and framing strategies. Environ. Innov. Soc. Transit. 33, 183–195. https://doi.org/10.1016/j.eist.2019.05.005.
Leipprand, A., Flachsland, C., 2018. Regime destabilization in energy transitions: the German debate on the future of coal. Energy Res. Soc. Sci. 40, 190–204. https://doi.org/10.1016/j.erss.2018.02.004.
Leutert, W., 2016. Challenges ahead in China's reform of state-owned enterprises. Asia Policy 21, 83–99. http://asiapolicy.nbr.org.
Li, J., Shi, P., Gao, H., 2010. 2010 China Wind Power Outlook [accessed 14 July 2020]. https://gwec.net/wp-content/uploads/2012/06/wind-report0919.pdf,/.
Li, J., Cai, F., Qiao, L., Xie, H., Gao, H., Yang, X., Tang, W., Wang, W., Li, X., 2012. 2012 China Wind Power Outlook [accessed 14 July 2020]. http://www.gwec.net/wp-content/uploads/2012/11/China-Outlook-2012-EN.pdf/.
Li, J., Cai, F., Qiao, L., Wang, J., Gao, h., Tang, W., Peng, P., Geng, D., Li, X., Li, Q., 2014. 2014 China Wind Power Review and Outlook [accessed 14 July 2020]. http://www.gwec.net/wp-content/uploads/2012/06/2014风电报告2英文-20150317.pdf/.
Lin, J., Kahrl, F., Yuan, J., Liu, X., Zhang, W., 2019. Challenges and strategies for electricity market transition in China. Energy Policy 133, 110899. https://doi.org/10.1016/j.enpol.2019.110899.
Liu, J., Wang, R., Sun, Y., Lin, Y., Xiao, L., 2013. A barrier analysis for the development of distributed energy in China: a case study in Fujian province. Energy Policy 60, 262–271.
Lockwood, M., Mitchell, C., Hoggett, R., 2019. Unpacking 'regime resistance' in low-carbon transitions: the case of the British Capacity Market. Energy Res. Soc. Sci. 58, 101278. https://doi.org/10.1016/j.erss.2019.101278.
Ma, X., Ortolano, L., 2000. Environmental Regulation in China: Institutions, Enforcement, and Compliance. Rowman & Littlefield Publishers, Lanham.
Mah, D.N.-Y., Wu, Y.-Y., Hills, P.R., 2017. Explaining the role of incumbent utilities in sustainable energy transitions: a case study of the smart grid development in China. Energy Policy 109, 794–806. https://doi.org/10.1016/j.enpol.2017.06.059.
Markard, J., 2018. The next phase of the energy transition and its implications for research and policy. Nat. Energy 3 (8), 628–633. https://doi.org/10.1038/s41560-018-0171-7.
Markard, J., Hoffmann, V.H., 2016. Analysis of complementarities: framework and examples from the energy transition. Technol. Forecast. Soc. Change 111, 63–75. https://doi.org/10.1016/j.techfore.2016.06.008.
Marvin, S., Guy, S., 1997. Infrastructure provision, development processes and the co-production of environmental value. Urban Stud. 34, 2023–2036. https://doi.org/10.1080/0042098975204.
Mori, A., 2018. Sociotechnical and political economy perspectives in the Chinese energy transition. Energy Res. Soc. Sci. 35, 29–36. https://doi.org/10.1016/j.erss.2017.10.043.
Mori, A., 2019. Temporal dynamics of infrasystem transition: the case of electricity system transition in Japan. Technol. Forecast. Soc. Change 145, 186–194. https://doi.org/10.1016/j.techfore.2017.05.003.
Mori, A., 2020. Foreign actors, faster transitions? Co-evolution of complementarities, perspectives and sociotechnical systems in the case of Indonesia's electricity supply system. Energy Res. Soc. Sci. https://doi.org/10.1016/j.erss.2020.101594.
Mori, A., Horii, N., 2020. Geographical diversification as a regime adaptation strategy? Insights from China's power generators. Presentation at the Society for Environmental Economics and Policy Studies 25th Annual Conference, 25 September 2020.
Mori, A., Liao, X., 2018. Carbon emission trading scheme and energy transition: the case of China local pilots. In: Presentation at the 6th World Congress of Environmental and Resource Economists. University of Gothenburg, 26 June 2018.
Mori, A., Takehara, M., 2018. Revisiting China's climate policy: the climate-energy conundrum point of view. In: Mori, A. (Ed.), China's Climate-Energy Policy: Domestic and International Impacts. Routledge, Abingdon, pp. 33–51. https://doi.org/10.4324/9781351037587-3.
Myllyvirta, L., Zhang, S., Shen, X., 2020. Will China Build Hundreds of New Coal Plants in the 2020s?, Carbon Brief [accessed 4 July 2020]. https://www.carbonbrief.org/analysis-will-china-build-hundreds-of-new-coal-plants-in-the-2020s/.
National Development and Reform Commission (NDRC), 2007. China's National Climate Change Programme. Beijing.
Negro, S.O., Alkemade, F., Hekkert, M.P., 2012. Why does renewable energy diffuse so slowly? A review of innovation system problems. Renew. Sust. Energ. Rev. 16 (6), 3836–3846. https://doi.org/10.1016/j.rser.2012.03.043.
Nilsen, T., 2017. Innovation from the inside out: contrasting fossil and renewable energy pathways at Statoil. Energy Res. Soc. Sci. 28, 50–57. https://doi.org/10.1016/j.erss.2017.03.015.
Oei, P.-Y., Brauers, H., Herpich, P., 2019. Lessons from Germany's hard coal mining phase-out: policies and transition from 1950 to 2018. Clim. Policy. https://doi.org/10.1080/14693062.2019.1688636.
Patala, S., Korpivaara, I., Jalkala, A., Kuitunen, A., Soppe, B., 2019. Legitimacy under institutional change: how incumbents appropriate clean rhetoric for dirty technologies. Organ. Stud. 40 (3), 395–419. https://doi.org/10.1177/0170840617736938.
Pennings, J.M., Barkema, H., Douma, S., 1994. Organizational learning and diversification. Acad. Manage. J. 37 (3), 608–640. http://www.jstor.org/stable/256702.
Pickl, M.J., 2019. The renewable energy strategies of oil majors – From oil to energy? Energy Strategy Rev. 26, 100370. https://doi.org/10.1016/j.esr.2019.100370.
Pierson, P., 1993. When effect becomes cause: policy feedback and political change. World Polit. 45 (4), 595–628. https://doi.org/10.2307/2950710.
Pierson, P., 2000. Increasing returns, path dependence, and the study of politics. Am. Polit. Sci. Rev. 94 (2), 251–267. https://doi.org/10.2307/2586011.
Planko, J., Cramer, J.M., Chappin, M.M.H., Hekkert, M.P., 2016. Strategic collective system building to commercialize sustainability innovations. J. Clean. Prod. 112, 2328–2341. https://doi.org/10.1016/j.jclepro.2015.09.108.
Reichardt, K., Rogge, K., 2016. How the policy mix impacts innovation: findings from company case studies on offshore wind in Germany. Environ. Innov. Soc. Transit. 18, 62–81. https://doi.org/10.1016/j.eist.2015.08.001.
Ren, B., Shou, H., 2013. Introduction: dynamics, challenges and opportunities in making a green China. In: Ren, B., Shou, H. (Eds.), Chinese Environmental Governance: Dynamics, Challenges and Prospects in a Changing Society. Palgrave Macmillan, New York, pp. 1–18.
Rentier, G., Lelieveldt, H., Kramer, G.J., 2019. Varieties of coal-fired power phase-out across Europe. Energy Policy 132, 620–632. https://doi.org/10.1016/j.enpol.2019.05.042.
Roberts, D., 2017. By 2020, Every Chinese Coal Plant Will Be More Efficient Than Every US Coal Plant: China's Efforts to Tackle Coal Are Comprehensive and Ambitious, a New Report Shows. Vox (16 May 2017), https://www.vox.com/energy-and-environment/2017/5/15/15634538/china-coal-cleaner/, [accessed 1 July 2017]..
Rogge, K.S., Johnstone, P., 2017. Exploring the role of phase-out policies for low-carbon energy transitions: the case of the German Energiewende. Energy Res. Soc. Sci. 33, 128–137. https://doi.org/10.1016/j.erss.2017.10.004.
Rui, H., Morse, R.K., He, G., 2015. Developing large coal-power bases in China. In: Thurber, M.C., Morse, R.K. (Eds.), The Global Coal Market: Supplying the Major Fuel for Emerging Economies. Cambridge University Press, Cambridge, pp. 73–122.
Seto, K.C., Davis, S.J., Mitchell, R.B., Stokes, E.C., Unruh, G., Ürge-Vorsatz, D., 2016. Carbon lock-in: types, causes, and policy implications. Annu. Rev. Environ. Resour. 41, 425–452. https://doi.org/10.1146/annurev-environ-110615-085934.
Shi, Y., Gillespie, A., 2020. China's energy system revolution. In: Shell International B.V, Development Research Center (DRC) of the State Council of the People's Republic of China (Eds.), China's Energy Revolution in the Context of the Global Energy Transition. Springer Open, pp. 390–590.
Smink, M., Simon, O., Negro, S.M., Niesten, E., Hekkert, M.P., 2015. How mismatching institutional logics hinder niche–regime interaction and how boundary spanners intervene. Technol. Forecast. Soc. Change 100, 225–237. https://doi.org/10.1016/j.techfore.2015.07.004.
Smith, A., Raven, R., 2012. What is protective space? Reconsidering niches in transition to sustainability. Res. Policy 41, 106–119. https://doi.org/10.1016/j.respol.2011.12.012.
State Grid Corporation of China, 2018a. 2016 Corporate Social Responsibility Report [accessed 26 June 2020] (in Chinese). http://www.sgcc.com.cn/html/files/2018-07/28/20180728130448830583544.pdf.
State Grid Corporation of China, 2018b. 2017 Corporate Social Responsibility Report [accessed 26 June 2020] (in Chinese). http://www.sgcc.com.cn/html/files/2018-08/29/20180829165036376453337.pdf.

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State Power Investment Corporation (SPIC), 2018. Overseas Corporate Social Responsibility Report [accessed 23 May 2020] (in Chinese). http://www.spic.com.cn/xxgk2/gkml/shzr/lnshzrbg/201807/P020180727583642360115.pdf/.
State Power Investment Corporation (SPIC), 2019. Corporate Social Responsibility Report 2019 [accessed 18 May 2020] (in Chinese). http://sp.spic.com.cn/shzrbg.zip/.
Steen, M., Weaver, T., 2017. Incumbents' diversification and cross-sectorial energy industry dynamics. Res. Policy 46, 1071–1086. https://doi.org/10.1016/j.respol.2017.04.001.
Stirling, A., 2014. Transforming power: social science and the politics of energy choices. Energy Res. Soc. Sci. 1, 83–95. https://www.sciencedirect.com/science/article/pii/S2214629614000036.
Teece, D., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. Strateg. Manag. J. 18, 509–533. https://www.jstor.org/stable/3088148.
Trencher, G., Healy, N., Hasegawa, K., Asuka, J., 2019. Discursive resistance to phasing out coal-fired electricity: narratives in Japan's coal regime. Energy Policy 132, 782–796. https://doi.org/10.1016/j.enpol.2019.06.020.
Turnheim, B., Geels, F.W., 2012. Regime destabilisation as the flipside of energy transitions: lessons from the history of the British coal industry (1913-1997). Energy Policy 50, 35–49. https://doi.org/10.1016/j.enpol.2012.04.060.
Turnheim, B., Geels, F.W., 2013. The destabilisation of existing regimes: confronting a multi-dimensional framework with a case study of the British coal industry (1913–1967). Res. Policy 42, 1749–1767. https://doi.org/10.1016/j.respol.2013.04.009.
Turnheim, B., Sovacool, B.K., 2020. Forever stuck in old ways? Pluralising incumbencies in sustainability transitions. Environ. Innov. Soc. Transit. 35, 180–184. https://doi.org/10.1016/j.eist.2019.10.012.
Uhde, H., Malima, G.C., 2020. Experimenting with local electricity markets in China – multilevel drivers and barriers in the sociotechnical regime. Energy Res. Soc. Sci. 69, 101577.
Unruh, G.C., 2000. Understanding carbon lock-in. Energy Policy 28, 817–830. https://doi.org/10.1016/S0301-4215(00)00070-7.
van Mossel, A., van Rijnsoever, F.J., Hekkert, M.P., 2018. Navigators through the storm: a review of organization theories and the behavior of incumbent firms during transitions. Environ. Innov. Soc. Transit. 26, 44–63. https://doi.org/10.1016/j.eist.2017.07.001.
Verbong, G., Geels, F., 2021. The ongoing energy transition: lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960-2004). Energy Policy 35, 1025–1037. https://doi.org/10.1016/j.enpol.2006.02.010.
Vormedal, I., Skjærseth, J.B., 2020. The good, the bad, or the ugly? Corporate Strategies, size and environmental regulation in the fish-farming industry. Bus. Polit. 22 (3), 510–538. https://doi.org/10.1017/bap.2019.30.
Vormedal, I., Gulbrandsen, L.H., Skjærseth, J.B., 2020. Big oil and climate regulation: business as usual or a changing business? Glob. Environ. Polit. 20 (4) https://doi.org/10.1162/glep_a_00565.
Wesseling, J.H., Niesten, E.M.M.I., Faber, J., Hekkert, M.P., 2015. Business strategies of incumbents in the market for electric vehicles: opportunities and incentives for sustainable innovation. Bus. Strat. Env. 24 (6), 518–531. https://doi.org/10.1002/bse.1834.
Wesseling, J.H., Lechtenböhmer, S., Åhman, M., Nilsson, L.J., Worrell, E., Coenen, L., 2017. The transition of energy intensive processing industries towards deep decarbonization: characteristics and implications for future research. Renew. Sust. Energ. Rev. 79, 1303–1313. https://doi.org/10.1016/j.rser.2017.05.156.
Wong, F., Sonail, P., 2014. China power plants exempt from ban on using low-quality coal: sources. Reuters (19 September 2014), http://www.reuters.com/article/us-china-coal-idUSKBN0HE0TU20140919/, [accessed 27 June 2017].
Wu, J., Zuidema, C., Gugerell, K., 2021. Experimenting with decentralized energy governance in China: the case of New Energy Demonstration City program. J. Clean. Prod. 189, 830–838. https://doi.org/10.1016/j.jclepro.2018.04.123.
Xu, M., Patton, D., 2019. China Datang-owned thermal power plant in Gansu files for bankruptcy. Reuters (28 June 2019), https://www.reuters.com/article/us-china-power-datang-coal/china-datang-owned-thermal-power-plant-in-gansu-files-for-bankruptcy-idUSKCN1TT1JG/, [accessed 19 June 2020].
Yang, C.-J., 2017. Energy Policy in China. Routledge, Abington.
Yao, K., Meng, M., 2016. China expects to lay off 1.8 million workers in coal, steel sectors. Reuters, 29 February 2016, http://www.reuters.com/article/us-china-economy-employment-idUSKCN0W205X/, [accessed 1 July 2017].
Yin, R.K., 2014. Case Study Research: Design and Methods, fifth ed. Sage Publications, Thousand Oaks, CA.
Zhu, X., Zhao, H., 2018. Experimentalist governance with interactive central–local relations: making new pension policies in China. Policy Stud. J. https://doi.org/10.1111/psj.12254.

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