



SINews *of* POWER

THE POLITICS OF THE STATE
GRID CORPORATION OF CHINA

XU YI-CHONG

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PREFACE

In the mid-1990s, a history professor at Peking University, who had just returned to China after spending over a year in the United States as a visiting professor, fascinated me by comparing the Chinese economy to the wild-west of the second half of the nineteenth century in the United States where the fittest survived in a lawless environment. I was not interested in Chinese politics then, and was taken back a little by his description of “those new capitalists” with entrepreneurial spirit and willingness to break rules in order to establish new rules. The three decades of economic reforms in China have indeed created a generation of such new entrepreneurs. They may be Communist Party members and hold important positions in state-owned enterprises. They know how to use their power and capacity to create new rules for themselves and others.

The recently retired chairman of the State Grid Corporation of China (SGCC) belongs to this group. During his tenure, despite all its “notoriety” among the public in China, SGCC turned from a residual government agency to the world’s largest utility company, with its investment and operation stretching into the five continents and its daring proposal of building global energy interconnection is welcomed by some and loathed by others. All these developments occurred despite, or perhaps because, SGCC is state-owned and supervised by the central government. SGCC thus provides an intriguing story to understand both the challenges facing the electricity industry and those presented by the Chinese elite state-owned enterprises (SOEs).

The immediate catalyst for this project was an invitation from Professor Thomas Rawski (University of Pittsburgh) and Professor Loren Brandt (University of Toronto) to contribute a piece on SGCC’s innovation efforts for their multi-disciplinary project on innovation in China. Several China scholars at the workshop commented that “we have heard so much about SGCC, but it is such a mystery that no one really knows how it operates.” As a consequence, a research project on SOE reforms, supported by the

Australian Research Council, became both a much narrower and a much broader enterprise. It is narrower because it focuses only on SGCC as a representative of a group of central SOEs in China. It is broader as it explores not only the relationship between “the state” and SOEs, the original topic, but also SGCC as a policy entrepreneur, technology innovator, and vanguard into global competition.

My gratitude goes to Tom and Loren whose initiative provided the impetus for this project; the National Academy of Economic Strategy, Chinese Academy of Social Sciences, to host me as a visitor; and Dannie Wang, Samuel Ankamah, and Julie Howe for their research assistance, and Maureen Todhunter, a professional editor, who made this book much more readable than initially written. Of course, all mistakes are mine.

At Oxford University Press, I could not have expected better professionalism than that from Scott Parris, Executive Editor, Economic and Finance, in New York and his assistant editor, Cathryn Vulman. I would like to thank Scott for his championing the book and five anonymous reviewers not only for their invaluable suggestions but also for their speedy reviews.

This study would not have been possible without insight provided by those working at the National Development and Reform Commission, SGCC, Chinese Academy of Sciences, and CASS. Even though I cannot publicly acknowledge the name of all these people I am indebted to, I am grateful for their help all the same.

Finally, this project jumped the queue. Now I am behind my part of the work on a joint project on international organisations. I appreciate the patience of my co-author, Pat Weller.

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Xu Yi-chong
Brisbane, Australia
June 2016

Sinews of Power

CHAPTER 1

The Politics of the State Grid Corporation of China

The State Grid Corporation of China (SGCC) is a state-owned utility company, responsible for planning, developing, and operating electricity transmission and distribution facilities over about 88 percent of China's massive territory. It is also responsible for providing retail services to 1.1 billion people. Emerging from an old-style, centrally controlled, yet decentralised and fragmented, inefficient government agency, SGCC is now the world's largest utility. It has ranked seventh every year on the Fortune Global 500 since 2011; its revenue of US\$339 billion in 2014 was larger than the gross domestic product (GDP) of most countries.¹ Its transmission networks absorb the world's largest amount of renewable sources of electricity generation (wind and solar photovoltaic, PV). Its ambitious cross-region ultra-high-voltage (UHV) transmission grids have already provided the country with an infrastructure framework that will have long-term lock-in effects on future development. In so doing, SGCC has built a brand globally and also helped some Chinese electric equipment manufacturers to have moved from being dependent on imports to being global competitive exporters. Internationally, SGCC has invested heavily in overseas markets, from Australia, Brazil, Italy, and Portugal to the Philippines; has pushed aggressively to become an international standard setter; and

1. The total revenue of SGCC in 2014 was on a par with the GDP of Denmark, which had the 34th-largest economy in the world.

recently has promoted its 'global energy interconnection' as a vision for the twenty-first-century grid.

Less than two decades ago, the electricity industry in China like that in most countries was vertically and horizontally integrated and state-owned, under the Ministry of Electric Power (MOEP). Like most state-owned enterprises, the power enterprises were inefficient, burdened with a redundant workforce and social responsibilities; many were loss-making. China suffered from perennial power shortages that impeded economic growth. The transmission networks were fragmented. A number of regions were still unconnected to the main systems. Investment in transmission and distribution (T&D) networks as a proportion of total investment in the industry was far behind that in developed countries. When SGCC emerged from the industry restructuring in 2002, few knew what to expect or how the new grid company would survive or behave. How has SGCC developed from a government agency, first to a horizontally and vertically integrated power company, and then to its current form as the world's largest utility company—'increasingly vertically integrated, internally funded, technology driven and multinational'—all the typical features of large corporations around the world?² What shaped these changes? There have been several suggestions: the market structure (SGCC's monopolised position), the ownership system (state-owned), the 'system of pyramidal control' of the party-state,³ direct involvement of the state, preferential government policies, SGCC as a political-economic powerhouse that controlled its own destiny, entrepreneurship of its management, or a combination of them all?

SGCC is one representative of an elite group of large state-owned enterprises (SOEs) administered and supervised by the central government. They dominate a few strategic industries, such as transportation, utilities (grids for water/natural gas/power), telecommunications, and defence. In a short period of 10–12 years (2003–2014), these central SOEs amassed enormous economic power and political influence. More importantly, they redefined the relationship between corporations and government, between corporations and society, and between China's corporations and the global

2. William G. Roy, *Socialising Capital*, Princeton, NJ: Princeton University Press, 1997; Charles Perrow, *Organising America*, Princeton, NJ: Princeton University Press, 2002; Michael Moran, *Business, Politics, and Society*, Oxford: Oxford University Press, 2009.

3. Barry Naughton and Kellee S. Tsai, eds., *State Capitalism, Institutional Adaptation, and the Chinese Miracle*, New York: Cambridge University Press, 2015, p.8.

market, signifying a fundamental change from the ‘visible-hand’ of government direct control to a ‘visible-hand’ of corporations. This book examines the evolution and development of SGCC in the context of two intertwined developments of electricity and SOE reforms, asking (a) how electricity restructuring shaped SGCC’s behaviour, its expansion, and, more importantly, its relationship with government; and (b) how its state-ownership has reshaped the interaction and relationship between the party-state and SGCC over time.

Both questions are important in their own right: first, after more than two decades of electricity reform, there is no agreement on either the structure of the transmission or the market design that would allow the ‘public good’ segment of the electricity industry—T&D and peak capacity—to work in a liberalised market system.⁴ Given the common physical attributes of the electricity industry everywhere, an understanding of the evolution of SGCC can offer some insight on the T&D industry and its market arrangements. Second, the relationship between government and business continues to be an intriguing issue for scholars—what is the ‘right’ mix of state and market? What are ‘the economic borders of the state?’⁵ As all governments have supported their strategic industries and national champions, how is the autonomy of corporations (regardless of their ownership) balanced with government intervention?⁶ How has state-ownership defined the relationship between the party-state and corporations? How has the relationship shifted over the past two decades in the electricity industry? The combination of these questions is particularly important as modern life cannot function without electricity and government has the responsibility to ensure safe, reliable, cost-effective, and sustainable electricity services for all. This book is therefore about these two intertwined reforms—electricity reforms and SOE reforms.

4. See, e.g., Thomas-Olivier Léautier and Véronique Thelen, ‘Optimal Expansion of the Power Transmission Grid: Why Not?’ *Journal of Regulatory Economics*, 2009, 36(2): 127–53; David Newbery, ‘Evolution of the British Electricity Market and the Role of Policy for the Low-Carbon Future,’ in *Evolution of Global Electricity Markets*, edited by F. P. Sioshand, St. Louis: Academic Press, 2013, pp.3–29; David Volk, ‘Electricity Networks: infrastructure and operations,’ IEA, 2013.

5. Dieter Helm, ‘Rethinking the Economic Borders of the State—ownership, assets, and competition,’ *Oxford Review of Economic Policy*, 2015, 31(2): 168–85.

6. See, e.g., OECD, *Strategic Industries in a Global Economy*, Paris: OECD, 1991; Oliver Falck, Christian Gollier and Ludger Woessmann, eds., *Industrial Policy for National Champions*, Cambridge, MA: MIT Press, 2011; Peter Nolan, *Is China Buying the World*, Cambridge, UK: Polity, 2011.

ELECTRICITY STORY

Electricity is everywhere: it reaches into our homes, bedrooms, offices, lamps, and computers; and it powers up all those appliances and pieces of equipment we depend upon daily. We as consumers often take electricity for granted—when we turn on the switch, lights are on, machines are operating, and air-conditioning is churning. We have become so dependent on it for our modern life that we notice it only when it is absent. Few of us know how it works, and even fewer pay any attention to its transmission and distribution network, commonly called ‘the grid’. What is the electric grid and what is it for? The grid, in its entirety, is a machine and indeed the most complex machine ever made; as Neil Armstrong said, it is the greatest engineering achievement of the twentieth century.⁷ ‘The electric grid is not a single *thing* but several things: a highway for delivering a product to millions of customers, a sort of NATO defense alliance of utilities pledged to help each other in time of need, a platform supporting a worldwide movement of information, and a commodities exchange dispatching vast resources on a second’s notice.’⁸ As electricity is not a physical substance but a process, taking place instantaneously throughout the network of wires, the grid occupies a central place in this process, playing a critical role in coordinating supply and demand and balancing current and frequency. How to coordinate, who is involved, what technologies are used, what the structure for such coordination is, and so on are not only technical and engineering questions. They are political issues.⁹ They are increasingly so now as the ‘power sector is undergoing one of the most profound transformation since its birth in the late 19th century’ toward low-carbon electricity production and consumption.¹⁰

Electricity and especially the electric grid may be a ‘rare’ topic of social science research; they are among the favoured subjects for those who have studied the rise of modern corporations around the turn of the twentieth century. The joined forces of technology inventors like Thomas Edison, financiers like J. P. Morgan, utility executives like Samuel Insull, and government officials determined ‘the technological form of electricity in central power stations rather than home generators or AC rather than DC’; the

7. Neil A. Armstrong, ‘The Engineered Century,’ National Press Club, 22 February 2000.

8. Phillip F. Schewe, *The Grid*, Washington, DC: Joseph Henry Press, 2007, p.1.

9. See the discussion provided, e.g., by Walt Patterson, *Keeping the Lights on*, London: Chatham House, 2007; MIT, *The Future of the Grid*, MIT, 2009; Stan Mark Kaplan, ‘Electric Power Transmission,’ Congressional Research Service, 14 April 2009.

10. IEA, *World Energy Outlook 2014*, Paris: OECD, 2014, p.202.

structure of the industry—vertically and horizontally integrated; and the rules of the game—services guaranteed by the industry in exchange for a monopolised position and guaranteed rate of returns.¹¹ These technologies, structure, and rules of the game dominated the industry for over one hundred years until the 1990s when electricity reform challenged the basic structure of the industry and altered the rules of the game.

There were three main components of the electricity reform: ownership reform (through the commercialisation, corporatisation, and privatisation of traditionally government-owned utilities), structural reform (by separating the main functions of the industry—generation, transmission, distribution, and retailing services), and regulatory reform. The key idea behind this reform package revised the traditional view of electricity as an engineering process and a public service to that of electricity as a commodity, which could be bought and sold. Thus the best way to ensure cost-effective electricity supplies would be through market competition. Markets and competition were considered better than government ownership and regulations to ensure economic efficiency and cheap services. The emphasis was thus not only on unbundling generation and retailing services from transmission and distribution so that competition could be introduced, but also on finding an ‘appropriate’ market design that would enable competition to work in this traditionally vertically and horizontally integrated industry, and developing a regulatory system that could oversee the natural-monopoly segments of T&D.¹² The well-accepted function of the grid to deliver electricity reliably from generators to end-users in a centralised manner was then challenged by demand that the grid operate as a marketplace. ‘The theoretical neatness of the free-market idea collides with the reality of electricity as a process [as] electric currents flow according to the laws of physics, not those of commerce.’¹³ After two decades of experiments, energy experts have not quite worked out a market structure

11. William G. Roy, *Socialising Capital*, Princeton, NJ: Princeton University Press, 1997, p.42; Richard F. Hirsh, *Technology and Transformation in the American Electric Utility Industry*, Cambridge: Cambridge University Press, 1989; William J. Hausman, Peter Hertner and Mira Wilkins, *Global Electrification*, New York: Cambridge University Press, 2008.

12. This is a large body of literature on the subject. See, e.g., Richard J. Gilbert and Edward P. Khan, eds., *International Comparisons of Electricity Regulation*, Cambridge: Cambridge University Press, 1996; Paul L. Joskow, ‘Introducing Competition into Regulated Network Industries,’ *Industrial and Corporate Change*, 1996, 5(2): 341–82; David M. Newbery, *Privatisation, Restructuring, and Regulation of Network Utilities*, Cambridge, MA: MIT Press, 1999; Xu Yi-chong, ‘Models, Templates and Current,’ *Review of International Political Economy*, 2005, 12(4): 647–73.

13. Walt Patterson, *Keeping the Lights on*, London: Chatham House, 2007, p.102.

that can ensure adequate investment in T&D while allowing competition in a liberalised market system. Meanwhile, transmission grids are under further pressure from government- and technology-led expansion of renewable sources of generation. The large-scale solar PV and wind stations and millions of rooftop solar systems demand more, rather than less, investment in transmission and distribution capacities. While required to provide reliable supply, grid companies and utilities are stuck with the costs of maintaining and expanding the grid and meeting peak-hour demand, with few means to make customers pay for it properly. Without adequate investment in the grids, reliable supply is at risk.¹⁴

SGCC emerged as the result of the global push for electricity reforms and for replacing government involvement with market competition. Its evolution and expansion took place at the time of global electricity transformation. SGCC is competing with its global peers to take control of the 'commanding heights' in managing the large-scale deployment of renewables with more volatile, real-time power flows, which in turn creates new challenges for the secure and reliable electricity supply that modern life is so dependent on. How has the unbundled electricity industry in China shaped the evolution of SGCC and its capacity to meet current challenges?

THE SOE STORY

There is no shortage of literature on state-owned enterprises in general and on the Chinese SOEs especially. Economic reform in China from the end of the 1970s onwards was very much about SOE reform. In the 1980s and early 1990s, SOEs were outperformed by non-SOEs (mostly collectively owned enterprises). On average, 'SOEs grew at 4.4 percent while collectives grew at the rate of 20.3 percent and private and foreign-owned enterprises grew at the rate of 28.9 percent.'¹⁵ SOEs and their poor economic performance were identified as the cause of multiple problems dragging down the economy: the aggregate slowdown after 1992, overstretched government revenues, extensive nonperforming loans in the commercial banking system, declining enterprise cash flows, rising job and income insecurity

14. Severin Borenstein and James Bushnell, 'The U.S. Electricity Industry after 20 Years of Restructuring,' *Annual Review of Economics*, 2015, 7: 437–63.

15. Quoted in Deborah Kay Johns, 'Reforming the State-Enterprise Property Relationship in the People's Republic of China: The Corporatisation of State-Owned Enterprises,' *Michigan Journal of International Law*, 16 (1994–95), 911–40, p.919.

in urban areas, slowing growth in rural income, deflation, and draining of government coffers through subsidies to loss-making SOEs.¹⁶ These inefficient economic dinosaurs with many 'unsolvable' social and economic problems presented the Chinese Communist Party (CCP) and government with 'the greatest challenges' and proved to be the 'ultimate test' of market reform.¹⁷

In the late 1990s, as the number of loss-making SOEs increased, the Chinese government started strategic reorganisation of SOEs while facilitating the withdrawal of state ownership. In the process, many small SOEs were privatised and the medium-sized and large SOEs were encouraged to form enterprise groups through commercialisation and corporatisation.¹⁸ This became known as the policy of 'grabbing the big and letting go of the small'. To manage and assist the process of commercialisation and corporatisation, the State Council in 2003 created the State-owned Assets Supervision and Administration Commission (SASAC). Following the previous period of restructuring, divestment, and mergers of small and medium-sized SOEs into large groups, the remaining SOEs became somewhat stronger in their capitalisation. Large SOEs were encouraged and assisted by SASAC to become globally competitive national champions with their 'well-known brand name, independent intellectual property rights, and clearly defined and strong core business.'¹⁹ SASAC also imposed more rigorous demands on these central nonfinancial SOEs. The role of SASAC in supporting and fostering this group of elite central SOEs in strategic industries is controversial because of unsettled debates about government involvement in economic activities.

16. Jeffrey Sachs, Wing Thye Woo, Stanley Fischer, and Gordon Hughes, 'Structural Factors in the Economic Reforms of China, Eastern Europe, and the Former Soviet Union,' *Economic Policy*, 1994, 9(18): 101–45; Wing Thye Woo, 'Improving the Performance of Enterprises in Transition Economies,' in *Economies in Transition*, edited by W. Woo, S. Parker, and J. D. Sachs, Cambridge, MA: MIT Press, 1998, pp.299–323; World Bank, *The Chinese Economy: Fighting Inflation, Deepening Reform*, Washington, DC: The World Bank, 1996b; John McMillan and Barry Naughton, 'How to Reform a Planned Economy: Lessons from China,' *Oxford Review of Economic Policy*, 1992, 8: 130–43; Gary H. Jefferson, Thomas G. Rawski, and Yuxin Zheng, 'Chinese Industrial Productivity: Trends, Measurement Issues, and Recent Development,' *Journal of Comparative Economics*, 1996, 23(2): 146–80.

17. Edward S. Steinfeld, *Forging Reform in China*, New York: Cambridge University Press, 1998, p. xv.

18. Barry Naughton, *Growing Out of the Plan*, New York: Cambridge University Press, 1996; Barry Naughton, *The Chinese Economy: Transitions and Growth*, Cambridge, MA: MIT Press, 2007; OECD, *Reforming China's Enterprises*, 2000, Paris: OECD, 2000.

19. Margaret Pearson, 'Governing the Chinese Economy: Regulatory Reform in the Service of the State,' *Public Administration Review*, 2007, 67(4): 720.

Most scholars have argued that the central government's reluctance to privatise its SOEs was ideological rather than economic. State ownership of the elite central SOEs is seen as the foundation of Chinese 'state capitalism', which 'captures China's combination of a predominantly market economy, emerging capital markets, and large and important government-owned corporations.'²⁰ The 'nationalistic connotation' of state capitalism is then extended to mean the elite SOEs are 'used as *instruments* of state policy . . . sent forth to battle for objectives the national government wants to achieve.'²¹ Setting aside the normative argument as to whether they should or should not, all governments from time to time create, support, and sometimes rescue national champions. The Chinese attempt to 'nurture national champion firms through state-led industrial policy measures . . . is exactly what all of today's high-income countries did in the past, from the late eighteenth century onwards.'²² How successful each national champion is within the same political system with similar policies is a core question of this book.

SGCC is one of the elite central SOEs. The central government decided from the very beginning that not only would SGCC be 100 percent state-owned but also its chief executive would be appointed through a joint decision of the Standing Committees of the Politburo and the State Council. Its evolution and expansion took place in the context of SOE reform and under SASAC's watch. As of the end of 2015, SGCC was full of contradictions: its business covered the natural monopoly parts of transmission and distribution, and also consisted of retailing services that were not officially open for competition but were much more decentralised in operation. It had a chairman of a board, even though the board did not exist; it transmitted and distributed the world's largest amount of solar and wind power; and it was considered a stubborn impediment in China's move to a low-carbon electricity industry. SGCC might have been used is also viewed as a convenient corporation to help government push through stimulus programs quickly and effectively, as seen at the end of the 1990s and again during the global financial crisis in 2008–09. It was also criticised by both

20. Barry Naughton and Kellee S. Tsai, eds., *State Capitalism, Institutional Adaptation, and the Chinese Miracle*, New York: Cambridge University Press, 2015, p.2. Also see, Sarah Eaton, *The Advance of the State in Contemporary China*, New York: Cambridge University Press, 2016; Benjamin L. Liebman and Curtis J. Milhaupt, eds., *Regulating the Visible Hand?*, New York: Oxford University Press, 2016.

21. Barry Naughton, 'The Transformation of the State Sector,' in *State Capitalism, Institutional Adaptation, and the Chinese Miracle*, edited by Barry Naughton and Kellee S. Tsai, New York: Cambridge University Press, 2015, p.66.

22. Peter Nolan, *Is China Buying the World?* Cambridge, UK: Polity, 2012, p.137.

government officials and the public for running its own ‘empire’ without subjecting to government policies. One of its original mandates was also to provide access to electricity to the remaining 8.5 million people, most living in very remote areas, often at very high altitudes and with harsh weather conditions. Meanwhile, SGCC was assessed by SASAC and other government agencies based on its financial performance.

To understand these contradictions, this study treats SGCC first and foremost as a corporation due to (a) its legal personality, (b) its separate ownership and management, and (c) its managerial hierarchy. Its legal status requires SGCC be responsible for its finances, internal structure, and operation, and thus provides it with autonomy to decide its strategies and to operate as a profit-making enterprise. Its separate ownership and management raises the important question of how and to what extent its ultimate owner—the state—can make it accountable. What is the relationship between SGCC and its owner—the state? Margaret Pearson has recently drawn our attention back to the classic work of Charles Lindblom on the separation of ‘systems of ownership (typically state versus private entities) from authority systems designed to organise the myriad decisions that are made in any economic system.’²³ The recognition that ownership is separated from decision-making authority requires us examine how decisions are made on both sides of the relationship—SOEs and the state—rather than assuming that ‘state ownership’ means state direct control.

EXAMINING SGCC THROUGH THE PRISM OF MODERN CORPORATIONS

This discussion of the development and operation of SGCC can be situated in reference to the rise of large corporations between 1860 and 1910 in the United States. The rise of large corporations in any economy tends to change its economic, social, and political life. The rise of large corporations at the turn of the twentieth century transformed enterprise capitalism into corporate capitalism in the United States and in some other European economies. It changed how corporations were run, how society was organised, and how politics were played. It signified a fundamental transformation from an ‘agrarian, entrepreneurial, locally oriented, and laissez-faire’

23. Margaret M. Pearson, ‘State-owned Business and Party-State Regulation in China’s Modern Political Economy,’ in *State Capitalism, Institutional Adaptation, and the Chinese Miracle*, edited by Barry Naughton and Kellee S. Tsai, New York: Cambridge University Press, 2015, p.28.

society of the nineteenth century to an 'industrial, corporate, nationally-oriented and bureaucratic statist' society of the twentieth century.²⁴ This transformation was attributed, by some, to the inevitable development of modern economies when firms adopted modern management and technological innovation,²⁵ and by others to 'the intensity of competition, both in marketing and in technological innovation, that made it difficult for the single firm to keep up with ever new developments year in and year out.'²⁶

Oliver Williamson and others meanwhile have long argued that multifarious activities in research, finance, manufacture, and marketing of products enabled firms to lower the transaction costs associated with these activities and encouraged firms to integrate vertically and horizontally and to centralise authority so they could engage in corporate consolidation.²⁷ Large-scale, vertically integrated corporations came to dominate many industries because of economies of scale and scope and because they were able to offer more than lower transaction advantages. These large corporations played a strategic role in the modern economy by taking risks of investment necessary to open up technological innovation. Alfred Chandler has gone so far as to argue it is not that markets shape business organisation, but rather that business organisations shape markets.²⁸

Firms and markets evolve together in shaping industrial outcomes. This interpretation of the rise of large corporations places ample emphasis on natural development—that is, it is the *raison d'être* of large corporations to concentrate, dominate, and monopolise. This 'natural' selection process, it is often argued, ensures more efficient firms prevail and rewards those firms that can rationalise and integrate the stages of production and

24. William G. Roy, 'Functional and Historical Logic in Explaining the Rise of the American Industrial Corporation,' in *Comparative Social Research*, edited by Craig Calhoun, Boston: JAI, 1990, volume 12, p.19.

25. Alfred Chandler pioneered this argument that when technological innovation increased the velocity of throughput (the speed at which raw materials move through the production process and are manufactured into finished products), firms could reduce the cost of production per unit and increase the output per worker, producing economies of scale that rendered administrative coordination more efficient than market coordination; consequently the 'visible hand' of hierarchy replaced the 'invisible hand' of the market. See Alfred Chandler, *Strategy and Structure*, Cambridge, MA: MIT Press, 1962; *The Visible Hand: The Managerial Revolution in American Business*, Cambridge, MA: Belknap, 1977; *Scale and Scope*, Cambridge, MA: Harvard University Press, Belknap, 1990.

26. Martin J. Sklar, *The Corporate Reconstruction of American Capitalism, 1890–1916*, New York: Cambridge University Press, 1988, p.165.

27. Oliver E. Williamson, *Markets and Hierarchies, Analysis and Antitrust Implications*, New York: Free Press, 1975.

28. Alfred D. Chandler, *Scale and Scope*, Cambridge, MA: Belknap Press, 1990; *Managerial Hierarchies*, Cambridge, MA: Harvard University Press, 1980.

build extensive distribution organisations under the control of managerially administered hierarchies. In contrast, others argue large corporations emerged at the turn of the twentieth century as the result of the *exercise of power* by government officials, financiers, and large industrialists. That is, economic activities such as producing, buying, selling, allocating resources, employing and de-employing labour, making contracts, establishing and directing partnership, and forming large corporations are indeed all exercises of ‘power in a political sense’. Large corporations are able to mobilise the resources of the society for the attainment of goals that they often claim to be “public” in nature because their capacity to mobilise resources is determined by virtue of their position in society.²⁹ Some focus on the internal structure of large firms to explain the exercise of power: that is, the internal operation of large corporations, the people who operate them, their goals and strategies, their division of labour, and the hierarchical structure often determine how they interact with the state. Others focus on the corporate managerial class with its network of industrial and financial capital that is able to escape oversight by the state, creating strong corporations and a weak regulatory state.³⁰ Despite different emphases, these studies all acknowledge the significant consequences of the rise of large corporations as economic institutions in shaping industries, society, and the dynamics of corporate politics in the United States and other countries.³¹

The internal structure of large firms is important to understand their rise and expansion. Yet, it is not sufficient. From the 1980s forward, under the rubric of ‘state-centric approaches,’ scholars turned their attention to the state, the corporate institutional structure, and especially the relationship between the state and large firms. They have asked to what extent the state can maintain its autonomy in its decision making, how and in

29. William G. Roy, *Socialising Capital: The Rise of the Large Industrial Corporation in America*, Princeton, NJ: Princeton University Press, 1997.

30. Especially see Neil Fligstein, *The Transformation of Corporate Control*, Cambridge, MA: Harvard University Press, 1990; and Charles Perrow, *Organising America*, Princeton: Princeton University Press, 2002. These different views of the rise of large modern corporation around the turn of the twentieth century were mirrored in the debate in China between large SOEs, which see themselves as market players, and the scholars, who emphasise how SOEs have manipulated their privileged positions and government policies to their own advantage.

31. See, e.g., Johann Peter Murmann, *Knowledge and Competitive Advantage*, New York: Cambridge University Press, 2003 on a comparative study of the rise of the dye industry in Britain, Germany, and the United States; Leslie Hannah, *Electricity before Nationalism*, London: Macmillan, 1979; Leslie Hannah, *The Rise of the Corporate Economy*, London: Methuen, 1983; Richard F. Hirsh, *Technology and Transformation in the American Electric Utility Industry*, New York: Cambridge University Press, 1989.

whose interests policy is made, why and how the state is ‘captured’ by large firms, and how institutional frameworks favour one set of policy alternatives over others.³² Without the state, the market—the master institution of modern society—cannot function. As David M. Hart pointed out, the state must be central to social science research on business development. The state shapes economic and corporate development as ‘a participant in markets, a channeler of financial flows, a maker of rules, and a creator of beliefs and attitudes.’³³ States are not generic. ‘They vary dramatically in their internal structures and relations to society.’³⁴ They are indeed a set of ‘institutional relationships, both formal and informal, that bind the components of the state together and structure its relations with society.’³⁵ To understand the relationship between the state and firms therefore requires an examination of how the state is organised, as its structure defines the range of responsibilities of the state in an economy and shapes its capacity for action.

While scholars had to make a case that the state played a key role in the rise of large corporations in advanced economies, few who studied Chinese political economy have failed to emphasise the role played by the state, or more precisely the party-state, in both economic and business development. Indeed, most studies have made little distinction between the party-state and elite central SOEs. One popular argument about the Chinese political economy is that ‘the state is regarded as a key agent—indeed, perhaps *the* key agent—to help create wealth through integration into world

32. There is a large body of literature on the state and market and it is from various angles and on both developed and developing economies. The earlier works include, for instance, Peter Evans, *Bringing the State Back*, New York: Cambridge University Press, 1985; Peter J. Katzenstein, *Small States in World Markets*, Ithaca: Cornell University Press, 1985. Also see, Martin J. Sklar, *The Corporate Reconstruction of American Capitalism, 1890–1916*, New York: Cambridge University Press, 1988; Neil Fligstein, *The Transformation of Corporate Control*, Cambridge, MA: Harvard University Press, 1990; Charles Perrow, *Organising America*, Princeton: Princeton University Press, 2002.

33. David M. Hart, ‘Corporate Technological Capabilities and the State,’ in *Constructing Corporate America*, edited by K. Lipartito and D. B. Sicilia, New York: Oxford University Press, 2007, p.183. Over thirty years ago, in a review article Stephen Krasner discussed the typology of the state—the state as administrative apparatus, legal order, and political beliefs—and the role of the state in economic development in the United States. There is a rich literature on the topic. See, for example, Peter J. Katzenstein, ed., *Between Power and Plenty*, London: University of Wisconsin Press, 1978; Stephen Krasner, ‘Approaches to the State,’ *Comparative politics*, 1984, 16(2): 223–46; and more recent, Fred Block and Peter Evans, ‘The State and the Economy,’ in *The Handbook of Economic Sociology*, edited by Neil J. Smelser and Richard Swedberg, Princeton, NJ: Princeton University Press, 2010, pp.505–26.

34. Peter Evans, *Embedded Autonomy*, Princeton: Princeton University Press, 1995, p.11.

35. Peter Hall, *Governing the Economy*, New York: Oxford University Press, 1986, p.19.

markets and to avoid problems caused by integration;³⁶ to 'draft' China's state-owned resource giants 'into service in supporting China's energy and resource security;³⁷ to protect inefficient SOEs at the expense of private sectors; or to create social and economic inequality. Statements such as the 'party-state still allocates economic resources,' 'the party-state still plays a role in the economy beyond the state-owned sector,' or 'the government in China continues to engage in all kinds of economic intervention' raise at least one question: What is this party-state?³⁸

The governing system in China is often seen as monolithic and therefore highly centralised, with the Standing Committee of the Politburo of seven to nine men at the apex of the hierarchies of the party, the government and the military. The Chinese Communist Party (CCP) is said to exercise a 'monopoly control of national policy and its implementation by the government and its general secretary has final authority for all matters.'³⁹ The central role of the CCP in government must be acknowledged as the party is fused into all institutions in China. It 'is not another bureaucracy of the state;⁴⁰ nor is it another key institution of the state. It is *inside*, *above*, and *around* the state institutions. To be more precise, the Standing Committee of the Politburo, the apex of the party hierarchy, consists of the president of the country and the head of the military, the chairman of the National People's Congress, the premier as head of government and his executive deputy, the head of the national political consultative body, the head of the CCP Discipline Commission, and the secretary of the CCP Central Committee. What the party decides matters, but the party and government are not in a top-down organisational and functional relationship. Governing SOEs is one of the key functions of the government.

Government is a collective entity. At the national level, the core executive of government, the State Council (or more precisely, the Standing

36. Tianbiao Zhu and Margaret Pearson, 'Globalisation and the Role of the State,' *Review of International Political Economy*, 2013, 20(6): 1219; Eric Thun, 'Industrial Policy Chinese-Style,' *Journal of East Asian Studies*, 2004, 4(3): 453–89.

37. Barry Naughton and Kellee S. Tsai, eds., *State Capitalism, Institutional Adaptation, and the Chinese Miracle*, New York: Cambridge University Press, 2015, p.9; Elizabeth C. Economy and Michael Levi, *By All Means Necessary*, New York: Oxford University Press, 2014.

38. Tianbiao Zhu and Margaret Pearson, 'Globalisation and the Role of the State,' *Review of International Political Economy*, 2013, 20(6): 1230; Barry Naughton and Kellee S. Tsai, eds., *State Capitalism, Institutional Adaptation, and the Chinese Miracle*, New York: Cambridge University Press, 2015.

39. Robert Lawrence Kuhn, *How China's Leaders Think*, Singapore: John Wiley & Sons, 2011, p.22.

40. Zheng, Shiping, *Party vs. State in Post-1949*, Cambridge: Cambridge University Press, 1997, p.13.

Committee of the State Council, SCSC) can be seen as the Chinese equivalent to the cabinet in Westminster systems. To govern, SCSC needs to coordinate with 25 key ministries, one special commission and many more central agencies, and also must coordinate with 27 provinces, 5 autonomous regions, and 3 municipalities. Governing does not happen by executive fiat: negotiations and compromises are inevitable in making decisions and deciding actions. Thus, instead of taking policy outcomes as given, we need to examine who is in charge of making what decisions, how decisions over these policies are made, why certain policy options are able to be debated and selected while others cannot even make it to the table; where ideas come from; whose ideas prevail and why; and many similar questions about governing. As in governments elsewhere, the potential sources of agenda items are diverse. It is critical for us to examine the decision-making process of the government to understand its relationship with central SOEs. The sweeping statement that the party-state controls central SOEs tells us little about the evolution, interests, strategies, or operations of these SOEs.

More importantly, the relationship between the party-state and corporations, especially state-owned, has to be explained as it is the core of modern political economy in China. The common argument is that as the party-state controls the appointment, removal, rotation, and assessment of those holding management positions of the central SOEs, these SOEs do the bidding of the party-state, no more and no less.⁴¹ While who is in the management position of a central SOE is important, it is problematic when appointment is translated to direct control too, not least because of the inevitable principal-agent slippage and shirking problems. The party-state effectively appoints only the very top tier of managers at central SOEs, and few of these managers have been transferred horizontally between the corporate world and government agencies. They tend to be industry experts. In most SOEs, the rest of the management team is recommended by chief executives and other industry insiders. The appointed chief executives are provided with a wide range of policy guidelines—‘going global’, ‘developing indigenous innovation’, ‘building globally recognised brand names’,

41. Ian Bremmer, *The End of the Free Market*, New York: Portfolio, 2010; Li-wen Lin and Curtis J. Milhaupt, ‘We are the (national) champions,’ *Stanford Law Review*, 2013, 65: 697–760. A few scholars have recently shifted their argument from state ownership to state control as the most fundamental problem with the Chinese political economy. Through the controlled allocation of resources, financial as well as human, the party-state is able to control all aspects of operations of central SOEs. See, for instance, Curtis J. Milhaupt and Wentong Zheng, ‘Why Mixed-Ownership Reforms Cannot Fix China’s State Sector,’ Paulson Institute Policy Memorandum, January 2016.

‘providing universal access to electricity’, and so on. This ‘state guidance’ is undeniably important as it prescribes an incentive structure within which all central SOEs operate. Broad policy guidelines are not so helpful in explaining why some central SOEs are active and successful in achieving these policy objectives while others fail to do so, what strategies each central SOE adopts in leading to its success or failure, or, more importantly, how they interact with various parts of the government in implementing these broad policy guidelines.

Focusing on the political and economic system often leads to sterile debates on ‘labelling’—whether capitalism in China is ‘centrally managed’, ‘authoritarian’, ‘state-led’, ‘entrepreneurial’, ‘oligarchic’, ‘or if it has a ‘socialist market economy with Chinese characteristics.’⁴² These consume the discussion, rather than offering explanations for the behaviour of corporations and their relationship with government agencies. This book therefore examines three dimensions: (a) the electricity industry and its challenges as the sectoral characters set the parameters for policy options and within which players operate; (b) changing institutional structures of both the state and corporations that not only defined their interests but also shaped their actions; and (c) empirical cases of SGCC in action. It particularly emphasises the decision making on both sides of the relationship—how government made decisions on electricity and SOE reforms that affected SGCC, and how SGCC developed its strategies and interacted with various parts of the government.

STRUCTURE OF THE BOOK

To understand the evolution, transformation, operation, and expansion of SGCC requires an examination of the intertwined reforms of electricity and SOEs. Exploring the technical complexities of T&D systems and challenges presented by technology innovation in the electricity industry allows us to appreciate the limited policy choices government has faced. The SOE reform cast light on the broader system of China’s polity, governing, and economy, especially regarding the changed relations between government and SOEs. The general argument of this book is that SGCC is a new type of

42. Special issue of *Management and Organisation Review* on ‘Chinese Capitalism’, 2011, 7(1): 1–189; Yasheng Huang, *Capitalism with Chinese Characteristics*, Cambridge: Cambridge University Press, 2008; Ronald Coase and Wang Ning, *How China became Capitalist*, Hampshire: Palgrave Macmillan, 2012; Christopher A. McNally, ‘Sino-capitalism,’ *World Politics*, 2012, 64(4): 741–76.

state-owned ‘profit-driven’ corporation: once it was given the mandate to construct, expand, and operate the national T&D system, it used its given autonomy to expand in a manner that was contentious for many domestic and international players. SGCC was managed by a group of political and economic entrepreneurs, whose Communist Party membership seldom dampened their enthusiasm to pursue corporate and individual interests that might not always align with those of the party-state (even assuming it did know what it wanted). As an embodiment of economic and political power, SGCC was willing and able to exercise such power. It had a propensity for unlimited expansion through merger and acquisition to squeeze out competition, and through technology innovation and global expansion to make itself adaptable and relevant.

Chapter 2 serves two purposes: it provides a background on electricity development in China and the challenges the industry and SGCC face. It also discusses electricity reform in general to highlight the key issues the transmission industry has had to manage. Global electricity restructuring towards deregulation and competition might have been initially driven in part by ideological considerations—to remove government from operating in the industry—but most segments of the industry still do not operate on market principles by following price signals.⁴³ While the debates continue around the world on what structure the electricity industry can and should have in order to achieve a bundle of objectives (reliable supply of cost-efficient electricity in an economically and environmentally sustainable way), the idea of a market-based electricity industry structured around competition was accepted and endorsed by many policy makers in China, who might not appreciate the technical complexities of the industry. These unsettled debates continue to complicate relationships between SGCC and government agencies in charge of macroeconomic policies.

Chapter 3 explains the reforms of the electricity industry in China that led to the creation of SGCC in 2002 and the debates that underpinned the changes that ensued. Each side of the debate had its political patrons, whose views on how the industry should or could be restructured, and why, varied significantly despite their shared technical training. Then premier, Zhu Rongji, reportedly told his colleagues, ‘Four of the seven members of the Standing Committee of the Politburo had their training in electrical engineering; wouldn’t it make the public laugh if we cannot get

43. For the discussion, see Severin Borenstein and James Bushnell, ‘The U.S. Electricity Industry after 20 Years of Restructuring,’ *Annual Review of Economics*, 2015, 7:437–63.

this right?’⁴⁴ The question of how to structure and restructure an industry, however, was political, demanding negotiations and compromises from all players. This process demands careful examination because it highlights the complex central and local relationships in China, the competing ideas of various government agencies, and difficulties senior officials of the electricity industry faced in transforming themselves into entrepreneurs.

Chapter 4 discusses the relationship between the party-state and the newly commercialised and corporatised SGCC by decomposing the party-state. It examines the governing structure over SGCC as the structure defines the range of the roles each government agency is capable of playing. ‘Outcomes depend both on whether the roles fit the context and on how well they are executed.’⁴⁵ It explains how and why the balance of power shifted in favour of large SOEs after the main reform in the early 2000s, who has what authority over these SOEs, and how the new structure allowed ‘able’ chief executives of central SOEs to take advantage of the malaises of the governing apparatus. Three key central government agencies are in this discussion: the State-owned Assets Supervision and Administration Commission (SASAC), which is widely seen as a key player in implementing ‘a dramatic shift’ to state capitalism in China; the State Electricity Regulatory Commission (SERC), which was hailed in the early 2000s for spearheading the creation of a ‘regulatory state’ in China; and the National Development and Reform Commission (NDRC) and its ‘half-sister’, the National Energy Administration (NEA). By focusing on the governing structure over central SOEs, this chapter shows how SGCC was engaged in a continuing reassessment of its scope for action and the intentions of those with whom it was interacting. This was a multidimensional and continuous process of interactions, as all actors, government agencies, and SGCC tested the bounds of what others would deem acceptable behaviour. In the process SGCC managed to exploit this divided structure of government in pursuing its strategies and its expansion.

Chapter 5 examines SGCC as a modern corporation—its legal status, operation, centralisation, and expansion. In 2003 when SASAC was established, the State Council placed 196 large, central SOEs under its umbrella. Central SOEs, however, varied in their legal status, the structure and the capacity of operating as a corporation, even though they were all owned and managed by the central government. This chapter explains why SGCC

44. 李其諺, 朱玥, 陈燕, 杨悦, 李毅, 电改试金石, 财经, 2013年3月24日 (Li Qiyang; Zhu Yue; Chen Yan; Yang Yue; Li Yi, ‘Touchstone of Electricity Reform,’ *Caijing Magazine*, 24 March 2013).

45. Peter Evans, *Embedded Autonomy*, Princeton: Princeton University Press, 1995, p.11.

operated under the old managerial responsibility system rather than under the Company Law. It also discusses the power of ‘institutionalisation’ of the transmission industry—before 2002, T&D always had to fight for attention and resources with the generation sector of the industry. Creation of SGCC in 2002 meant that, for the first time in China’s electricity history, transmission and distribution as infrastructure and as an industry were placed under one umbrella and with one set of corporate interests. It was in the interest of SGCC to seek greater economies of scale, greater gains from vertical integration, and greater speed and coordination of production flows. If expansion is the natural feature of corporations, the way SGCC pursued its expansion deserves investigation because such an expansion may or may not have been in the ‘public’ interest or aligned with what political leaders sought to achieve initially. In the process of building a hierarchical corporation by absorbing regional, provincial, and county entities, and acquiring or aligning with manufacturing firms to reduce costs and squeeze out competitors, SGCC changed its relationship with various government agencies, local governments, and its counterparts.

The second part of this book analyses SGCC in action, as a policy entrepreneur, a technology innovator, and a vanguard for China’s global expansion. Chapter 6 examines how SGCC acted as an active strategic policy entrepreneur. In China even the key SOEs do not automatically have a ‘right’ to participate in the policy-making process, nor are their interests represented automatically by government agencies, whose interests do not always align with each other anyway. Over any given issues, there are competing demands for ‘framing problems’ and ‘suggesting policy options’. To get what they want, the key SOEs have to act as active policy entrepreneurs, participating in ‘both the high politics, and routine politics, of economic life.’⁴⁶ This chapter discusses the strategies that SGCC deployed to place the controversial UHV project on the policy agenda and its capacity to turn its strategy into a political reality. This process is unlike that in a pluralistic society, where there is open competition among multiple players and competing inputs, or in a democratic corporatist system where ‘relatively centralized and concentrated’ interest groups are integrated in ‘voluntary and informal coordination of conflicting objectives through continuous political bargaining’ with bureaucracies and political parties.⁴⁷ Unlike these two systems, the winners of the nontransparent, or more precisely

46. Michael Moran, *Business, Politics, and Society*, Oxford: Oxford University Press, 2009, p.63.

47. Peter J. Katzenstein, *Small States in World Markets*, Ithaca: Cornell University Press, 1985, p.32.

non-institutionalised, policy-making process in China are those who are willing to take risks and devote resources, and are strategic in providing ideas and advice to policy makers in the process of agenda setting. In so doing, they are able to influence the prevailing narratives and foster political support. SGCC also had the information, knowledge, and resources to support its efforts as an active policy entrepreneur.

Chapter 7 examines how SGCC pursued technology innovation in undertaking the UHV projects. Technology innovation is a key element in the evolution of business organisations.⁴⁸ Technology is neither non-political nor interest-neutral. Its selection is a political process where various interests compete, and those with ideas, resources, and political influence tend to win. To illustrate how SGCC tackled issues of innovation, this chapter concentrates on two aspects: how internally SGCC built a team of researchers and a set of institutions that engaged in applied research, and how externally it build alliances that changed China's high-end electric equipment manufacturing industry. The argument that China has pursued 'techno-nationalism' by subsidising and supporting its SOEs in developing indigenised technologies and in taking control over the command heights in international competition⁴⁹ tells at best only one part of the story—the story of the Chinese government policies of technology development. It misses the main driver behind technology innovation—corporations. That is, the argument of China's tech-nationalism tells us little why some SOEs have innovated while others failed to do so. After all, firms are on the forefront of technology innovation. This chapter explains how SGCC acted and reacted to government policies in pursuing innovation.

Chapter 8 examines the two-pronged internationalisation of SGCC—its global expansion and active participation in a global standard setting. Global expansion, a hallmark of all large corporations, empowers corporations in their bargaining position with government and with their overseas counterparts. SGCC aggressively engages in the global race by building its national and international brand, pursuing international standard setting, and investing heavily in international markets—as a passive investor in some countries while constructing, operating and managing grids in

48. Alfred D. Chandler Jr., *Scale and Scope: The Dynamics of Industrial Capitalism*, Cambridge, MA: Belknap Press, 1990; Alfred D. Chandler, Jr., Franco Amatori and Takashi Hikino, eds., *Big Business and the Wealth of Nations*, New York: Cambridge University Press, 1997.

49. Andrew B. Kennedy, 'China's Search for Renewable Energy,' *Asian Survey*, 2013, 53(5): 909–30; Barry Naughton and Adam Segal, 'China in Search of a Workable Model,' in *Crisis and Innovation in Asian Technology*, edited by William W. Keller and Richard J. Samuels, New York: Cambridge University Press, 2003, pp.160–86.

others. Its internationalisation efforts could hardly be seen as instructed by the party-state. This chapter also demonstrates a symbiotic relationship between these two paths to internationalisation—expansion into the global markets and participation in international standard setting that provided ‘technical legitimacy’ for its UHV technologies to go global.

In sum, this book seeks to explain the relationship between the party-state and SOEs in China by using SGCC as an example. This relationship is neither top-down nor unidimensional. What is to be produced, where, and how are in the domain of business, which makes decisions within a set of incentive structures that are created by the market as well as government policies. While the government can profoundly influence the outcome of market activities by determining the nature and distribution of property rights and the rules governing economic behaviour, how it exercises its authority in decision making and how it considers the potential adverse effects on large players in the economy needs to be explained. After all, a modern economy cannot function without electricity; the centre of the electricity system is the T&D, linking together hundreds of producers and millions of end-users, balancing their unpredictable demands, enabling an increasing share of low-carbon generation, and ensuring secure and reliable electricity services. It provides the sinews that enable the body politic to work.

CHAPTER 2

Electricity

Electricity is a shapeless, invisible, and intangible form of energy. Modern society cannot function without it, but it is seldom noticed by those who consume it. Electricity is more than a ‘strange product’; it is a complex physical and engineering system. At its centre is the transmission and distribution (T&D) system, or the grid. The electrical grid is not a single thing: it is a ‘highway’ that transports electric currents through appropriate wires, and a complex machine that synchronises supply and demand with fine adjustments of vital parameters (voltage and frequency level) in delivering service to millions of end-users. The electricity grid is equivalent to the human blood circulation system, functioning as the central nervous system of an economy and a society. The grid is being revolutionised as a concept, infrastructure and as industry, driven by a combination of political demand and new technologies. This is the industry that the State Grid Corporation of China (SGCC) is mandated to operate.

The grid, however critical, is just one segment of the electricity industry. This chapter sets the context for exploring SGCC through an overview of how the electricity industry developed in China and globally. It begins with a broad look at the electricity industry in general, including its physical and engineering principles. The second section provides a brief summary of the electricity industry in China—its development and challenges—especially in the past two decades. The third section discusses the electricity reform that has swept across the globe since the early 1990s, thus highlighting challenges facing the transmission industry in general. The final section lays out some specific challenges facing SGCC.

The general messages in this chapter are that (a) electricity is essential for modern society, (b) the electricity industry is governed by a set of physical features, (c) electricity development in China has to be discussed in the context of both economic reform in China and overall global electricity reform, and (d) SGCC is mandated to operate an industry that is known for its natural monopoly. This discussion reveals that although electricity itself is invisible and intangible and the electricity industry is bound by physical features, development of this industry is defined by its complex politics in China as well as internationally.

THE ELECTRICITY INDUSTRY

An electricity system comprises four interacting physical elements: *energy generation*, *high-voltage transmission*, *lower-voltage distribution*, and *energy consumption* (also known as load). Two other important elements are less tangible: 'the operational systems that protect and control the physical elements, and the regulatory and governance structure that shapes the system's evolution.'¹

Energy generation is the process of converting any of a variety of energy resources, such as water, sun, coal, oil, natural gas, and wind, into electric currents. It is usually performed by power stations on a large scale relative to the usage of individual end-users, and occurs at a considerable distance away from end-users. These electric currents are sent to substations where they are 'stepped up' to a higher voltage to reduce losses, and then travel over long distances through transmission networks. High-voltage transmission thus consists of two main functions—transporting and synchronising. First, it is transporting electric currents from a large number of generation stations through high-voltage wires, transformers, and substation facilities (where the voltage is reduced); overhead or underground distribution lines then carry the electricity to end-users. In this process, electricity does not have a 'brand'; once generated and sent to the grid system, end-users have no way of knowing whether they consume 'dirty' (e.g., fossil fuels) or 'clean' (renewable) sources of electricity, or who the producers are. Yet, as end-users, all consumers suffer the (potential) consequences of converting natural resources to electric power, whether air, land, or/and water pollution from burning coal; potential or actual radiation from nuclear power plants; or the socioeconomic costs from events such as shutting down gas

1. MIT, *The Future of the Electric Grid* Boston, MA: MIT Press, 2009, p.1.