The dragon awakens: innovation, competition, and transition in the energy strategy of the People's Republic of China, 1949 to 2017

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The Dragon Awakens: Innovation, Competition, and Transition in the Energy Strategy of the People's Republic of China, 1949 to 2017

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Abstract: Based on a mix of original archival research and an extensive review of the contemporary peer reviewed literature, this article reviews the history of the People's Republic of China's national energy policies since 1949. We divide this history into six phases: Emergence (1949–1957), Socialist construction (1958–1965), Turbulence (1966–1978), Reform (1979–2000), Contestation (2001–2014), and transition (2015-present). Over the whole history of more than sixty years, China's energy production and consumption grew at a surprising speed, while energy intensity exhibited early fluctuations and a subsequent gradual decrease after the turbulence phase. In tracing this history, the article offers new historical and policy insights into the world's largest developing country and a theoretical contribution to the role of the state in shaping economy and society through energy policy. The article lastly offers an in-depth exploration of how command-and-control style administrative intervention and low levels of market liquidity have had a prophylactic effect on innovation and competition.

Key words: China; energy security; energy sustainability; energy strategy

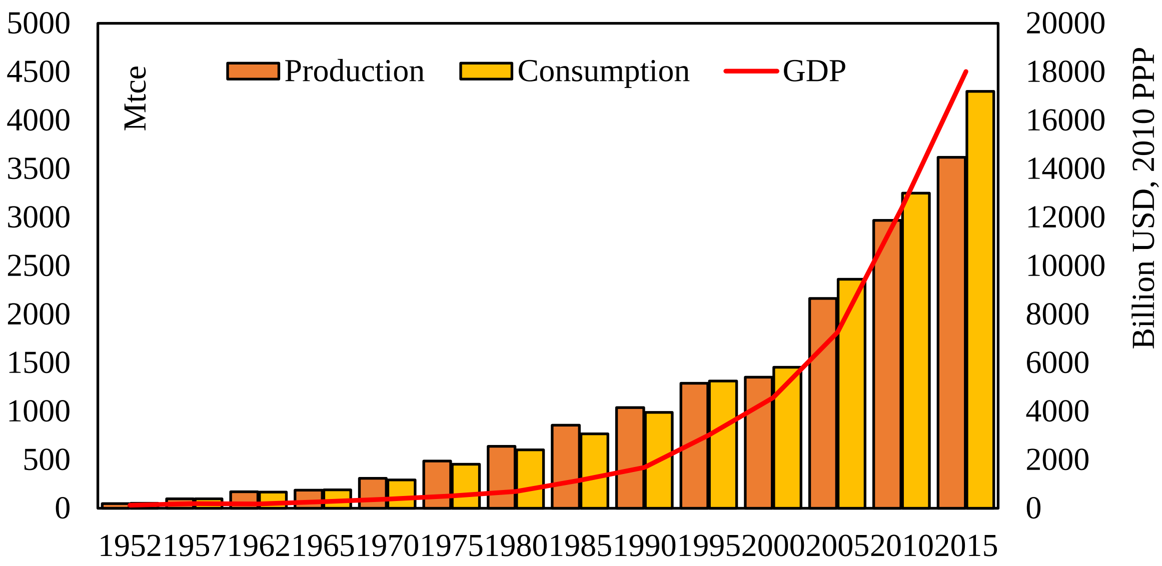
1. Introduction

Since the formal birth of the People's Republic of China (PRC) in 1949, the nation has grown considerably in terms of its economic and social development. Whilst the country's outstanding and prolonged economic growth over the last forty years has drawn significant scholarly attention (Naughton, 2007; Zheng et al., 2008; Yueh, 2013), one key driver of such advancement has been studied in less detail: energy production and use.

Energy supply and utilization, including its interaction with technology, has long been recognized for its central role in economic growth (Kaufmann, 1992; Daly, 1997; Ockwell, 2008; Simieniuk, 2016) and in the broader shaping of societies (Urry, 2014). These insights raise questions about state power and influence (Tyfield, 2014), but few if any studies illuminate the role of deliberate state intervention in shaping energy systems and simultaneously shaping economy and society. This paper contributes to filling this gap by drawing on archival data and relating the history of China's energy strategy (with shifting political objectives) to the country's changing economy over the six decades since the birth of the Republic. In so doing, it provides an important historical framework for understanding China's current efforts to transition to a lower carbon economy – a question of scholarly interest (Shen, 2016) and of global concern (Liu, 2016; Gallagher, 2009).

In its nascent days as a sovereign communist country, the PRC confronted devastation and poverty caused by war and social unrest. Sixty years later, almost all statistics have shown that China is the world's largest energy consumer, the biggest emitter of greenhouse gases, the fifth largest producer of oil, seventh largest producer of natural gas, and the largest producer of coal. Thus, from 1949 to the present, China's centrally planned economy progressed through periods of industrialization and modernization, with rapidly expanding energy production and consumption. For example, from 1952 to 2014, China's energy production rose from 48.7 million tons of coal equivalent (Mtce) to 3600 Mtce (NBSC, 2014), and an ascent graphically depicted in Figure 1. Over this period, China's energy production and consumption increased by a factor of about 75, with an average annual growth rate of 7.3 percent. During most of this time, this country was self-sufficient in its energy production. However, since the 1990s, the gap between production and demand has expanded, leading to an escalated dependence on imported fuels, mainly oil (Nolan et al., 2004). In fact, China has been a net oil importer since 1993, and dependence on imported oil rose to 60 percent in 2014 (British Petroleum, 2015). Despite its prodigious coal resources, China even emerged as a net coal importer in 2009, when it imported more than 100 Mt of coal that year (British Petroleum, 2010). Over the period examined, the Chinese energy system underwent a major transformation. In 1952, the mix of energy consumption was composed by 95 percent of coal, but in 2013, it was composed by 66 percent of coal, 19.4 percent of oil, 5.8 percent of natural gas and 9.8 percent of other energy sources (NBSC, 2014).

Figure 1: Energy production and consumption in the People's Republic of China, 1952 to 2015



Source: Compiled by authors based on data from China Statistical Yearbook. Note: Mtce = million tons of coal equivalent.

In this article, we explore a variety of supply and demand side changes in China's energy strategy over the previous decades. These relate to periods of political and social unrest, the transformation from a planned to market economic system, and the challenge of global and international situations. In doing so, the article attempts to make multiple contributions. Firstly, it offers historical and policy insight into the world's largest developing country. China has become the world's largest energy consumer and producer for several years, contributing to 23 percent of world energy consumption in

2014 (British Petroleum, 2015). That same year, it strikingly contributed to 61 percent of the world's total increases in annual energy consumption.

Secondly, tracing the history of Chinese energy strategy reveals the source of several remaining health and social challenges including air pollution, economic competitiveness, and the emission of greenhouse gases. For instance, China is among the countries with the lowest rates of energy efficiency in the world, and one study estimated its efficiency was 10 percent lower than the average for developed countries (Crossley, 2013).

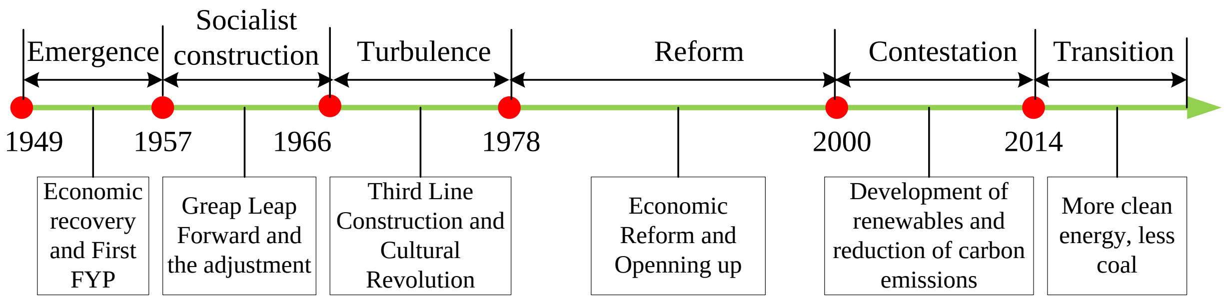
The article lastly offers an in-depth exploration of how command-and-control style administrative intervention and low market liquidity have resulted in lack of comparative progress in innovation and competition. China's model of a planned economy is meticulously examined against the backdrop of national priorities such as energy security, and energy sustainability, providing a historical framework for understanding current efforts to transition to a low carbon economy.

Our primary source of data for this article was historical records and archives. We analyzed national Energy Statistics Yearbooks and some other statistics materials available only in Chinese (and mostly only in print) since 1952, using libraries in Beijing. We also relied on archives recording the main decisions and policies of the Chinese Government, sources admittedly edited by the CPC Literature Research Center but published by the Central Literature Publishing House in the 1990s. We then supplemented these sources of material with peer-reviewed assessments of the history of Chinese energy policy and security, especially those from the energy studies literature and online Chinese databases such as China National Knowledge Infrastructure (CNKI). Our results suggest that most research has focused on China's recent energy security concerns, with the "earliest" studies tracing the economic reforms of the late 1970s (Hang and Tu, 2007; Zhao and Hong, 2010). In this paper, we try to go much further back to 1949 and present this chronicle through an original assessment of six historical phases.

2. Six Phases of Chinese Energy Strategy: 1949 to 2017

The essence of the Chinese communist state during the nascent years of its energy planning apparatus lay in state management of public assets, or direct government intervention in the economy. Despite this interventionist approach steered by sequential Five-Year plans, there is much variety in the genesis and evolution of national Chinese energy strategy. We divide the history of the last 60 years into six phases: Emergence (1949–1957), Socialist construction (1958–1965), Turbulence (1966–1978), Reform (1979–2000), and Contestation (2001–2014), and Transition (2015-present) (see Figure 2).

Figure 2: Six historical phases of the People's Republic of China's energy strategy



2.1 Emergence (1949–1957)

At the birth of the People's Republic of China, the nation was emerging after years of war and turmoil, as well as a fairly high degree of political and social chaos. Thus, early planners focused intently on economic recovery and the establishment of industrial infrastructure. Due to the effects of conflict, energy production in China continued to decline from 1948 to 1949, with coal and electricity production only half of their highest pre-war levels. Once the new government had been formed it set up the Ministry of Fuel and Industry as a national energy governing body. It tried to resurrect inherited coal, oil, and electricity supply stations, forecast additional production plans, and direct investment into the fuel and power sectors.

During this period of economic recovery, the government took a series of largely favorable measures which had a noticeable, positive affect on energy strategy. By 1953, the economy had almost recovered to pre-1949 levels, and the government established its first FYP, which aimed at laying the foundation for a socialist industrial system. From the very beginning, the government took the former Soviet Union as its exemplar. Thus, it focused on the goal of energy production and directed investment to heavy industry, including raw materials and mechanical manufacturing. During the first FYP, the energy industry received 28.7 percent of national industrial investment, including 12 percent directed towards the electricity sector, 11.9 percent to the coal sector, and 4.8 percent to the oil sector (CPC Literature Research Center, 1992a). Since the economic policy focused on industrial production, planners suggested that the growth of the energy sector should be even higher than that of core assets such as steel. In terms of hydropower development, the policy paid more attention on the construction of small- and middle-sized hydropower plants, and tried to build a few large ones to prepare for the future expected increases in demand for electricity.

However, the demand for coal turned out to be much greater than expected, because the economy grew much faster than anticipated. In order to meet the demand for energy, the government strictly controlled domestic energy markets and promoted energy conservation across industry (CPC Literature Research Center, 1992b). With the continued development of the planned economy, the government needed to make more precise production plans. Hence, the Ministry of Fuel and Industry was decomposed into three parts: the Ministry of Coal Industry, the Ministry of Electricity Industry, and the Ministry of Oil Industry.

It was during these early, formative years that spatial distribution of functions also began to solidify. During the time of economic recovery, most coal projects were initiated in the Northeast Region, while the production mainly came from the Northern and Eastern China (Chi, 2005). This led to a geographical mismatch between sources of energy extraction, production and energy demand that continues today. Shanxi and Inner Mongolia, the two provinces with the largest reserves of coal, would come to account for almost half of China's total coal production over the next few decades (Natural Resources Defense Council, 2010). The government also sought to restore its oil industry to satiate demand for oil across the national defense, transportation, and industry sectors (Chinese Academy of Social Sciences & the State Archives Administration of PRC, 1989).

After three years of recovery, raw coal production doubled and reached a historical record of 66 million tons (Mt). Crude oil production rose up to 0.44 Mt, 3.6 times of that in 1949, and 1.3 times of the highest previous level (State Power Corporation, 2001). In addition, with the help of the Soviet Union, several large energy projects were initiated, especially cooperation in the design and use of mining technologies and power stations. These efforts bore fruit, and by the end of the first FYP, national energy production had risen to 98.6 Mtce in 1957, a doubling over 1952 levels (State Power Corporation, 2001). GDP also rose from 67.9 billion RMB (about 127 billion USD, 2010 PPP) to 106.8 billion RMB (about 198 billion USD, 2010 PPP), with an annual growth rate of 9.5 percent.

Though energy production made considerable progress in this phase (Shi, 1996), there were still countervailing pressures. Firstly, energy policy at that time focused on the recovery of inherited coal mines and industrial centers, and failed to initiate enough new energy projects to meet all demand. Secondly, this so-called "catch-up strategy" affected the establishment and implementation of energy policy, with planners focusing on the ends (greater supply), rather than the means (harnessing energy from a variety of sources) in what has come to be known as technological agnosticism (Xie, 2006), admittedly contributing towards the "lock-in" of coal.

2.2 Socialist construction (1958–1965)

Emboldened with the success of the first FYP, and driven further by policy priorities focusing on the desire for socialist economic development, energy planners set increasingly aggressive goals in the following years, but emphasized compatibility with the formation of China's socialist, centrally planned economy.

During the Great Leap Forward of 1958-1960, a cooperative system of agriculture, the country's main source of revenue and employment, went through "convulsive changes" as Rural People's Communes were created, and peasants could no longer sell their output on free markets (Borensztein and Ostry, 1996). Prices for most goods were fixed by the government, especially key agricultural commodities such as rice and flour, and non-state firms were restricted in their access to both credit and customers. Agricultural production was distorted by heavy-handed regulation of grain output. Labor markets were abolished, and basic laws of exchange, contract, and property rights were diluted (McMillan and Naughton, 1992). In China it was during this time that "virtually every aspect of social life—even friendship, music, and language—became entangled with centrally imposed rules" (Rawski, 1999). Under this system state-owned enterprises grew to account for more than 70% of investments in the country as well as more than 70% of credit. This created what theorists have called a "rigid central planning system" distinguished by the "preponderant role of state enterprises and considerable state interference in economic activity" (Borensztein and Ostry, 1996).

This interventionist and centralized economic model seemed to pay dividends, and became further entrenched as output per worker grew at an average rate of 5.9% for the period of 1953 to 1978. Over the same period, increases in "every imaginable indicator of economic performance" occurred, including output, productivity, employment, incomes, exports, literacy, education, and life expectancy (Rawski, 1999). This all served to validate faith in a centrally planned economy.

Indeed, archival evidence suggests that the goals of the first FYP were achieved in advance in 1957, and such progress inflated government confidence (CPC Literature Research Center, 1994). Thus, the second FYP (1958-1962) was aimed at enhancing the national industrial strength by improving steel production and realizing the ambitious goal of rapid industrialization and modernization (Zha, 2005). The second FYP, prepared in August of 1958, took steel as a key link in heavy industry, which meant the production of other products was planned based on steel production (CPC Literature Research Center, 1995). This saw a reported doubling of steel production in an astonishingly fast three months (CPC Literature Research Center, 1995). The Ministry of Coal Industry even projected (wrongly) that Chinese coal production would exceed the production of the United Kingdom in 5 years and overtake the United States in 15 years. In the electricity sector, decision-makers also sought to increase the installed capacity from 6.29 GW to 15 GW between 1958 and 1965 and to increase electricity production from 27.5 TWh to 67.6 TWh (State Power Corporation, 2001). One prong of this approach was to plan hydropower plants on a nation-wide scale, regardless of the distribution of water resources (People's Daily, 1958).

This period of socialist construction was deeply intertwined with significant enhancements in national energy production through exploration of new sources. From 1958 to 1961, 23.7 billion tons of coal reserves were deemed technically proven and economically recoverable, and more than 800 oil-bearing geological structures were found. Among them, three were identified as bearing rich oil resources (CPC Literature Research Center, 1997a). In 1958, the discovery of the Karamay Oilfield became the first breakthrough of the PRC's nascent oil industry, and the Daqing Oilfield, found in 1959, became another milestone. Whilst falling short of the competitive ambitions of the Ministry of Coal Industry, 324 Mt of coal capacity was added, as well as 5 Mt of oil capacity, and installed power capacity increased from 6.29 GW to 7.5 GW (State Power Corporation, 2001).

Things started to stall, however, in the late 1950s and early 1960s. In 1959, policymakers dropped their previous targets for developing hydropower across the whole country and decided to revert back to the construction of more coal-fired power plants. Due in part to natural disasters and growing hostility with the former Soviet Union, the country faced unprecedented economic difficulties in 1961 (Zha, 2006). From then, the central government began consciously to adjust its economic structure. It altered the shares of different industrial sectors, gave up the key position of steel in production plan preparation (thus reducing investment in the steel industry), and focused on the improvement of product quality and productivity (CPC Literature Research Center, 1997b).

An overall decline in energy production was observed when the Great Leap Forward ended, because the zealously enforced economic targets went against the trends in supply and demand. Coal production dropped dramatically, from the peak of 397 Mt in 1960 back to 217 Mt in 1963, then further decreased to 214.57 Mt in 1964 (State Power Corporation, 2001). From 1958 to 1961, the total additional coal production capacity reached 324 Mt, but by 1963, only 10 percent (32.7 Mt) of capacity was in production. For example, more than 30 coal mines were constructed in the southern part of Hubei Province during the three years, but only one was put into operation (National Economic and Trade Commission, 2000). The same thing happened in the electricity sector: 48 thermal power projects (about 2 GW) and 18 hydropower projects (about 4.9 GW) were shut down or postponed between 1960 and 1965 (State Power Corporation, 2001).

2.3 Turbulence (1966–1978)

This slowing down of national energy production precipitated a period of severe turbulence by 1966, when the Cultural Revolution swept the country. Before that, the government initiated the Third Front Movement in 1964. This process lasted for more than a decade, greatly affecting the development of China’s economy.

After the Great Leap Forward ended, the PRC experienced some problems and misjudgments around economic development. In order to protect its industrial development from potential foreign military intervention or subversion, the government deployed the Third Front Movement—economic construction activities in Northwest and Southeast China to prepare for a potential coming war. Before the Third Front Movement, China’s energy industry was mainly distributed in the Northeast and North, which were vulnerable to foreign military forces. Thus, in order to develop the resources in Southwest and Northwest China, and to enhance the national defense its industrial infrastructure, China began to reorient energy investments towards other provinces. The Third Front Movement was implemented from 1964 to 1980, involving three FYPs and covering 13 central and western Chinese provinces. It was a major adjustment of China’s industrial distribution, including the energy industry.

In practice, the Third Front Movement refocused oil and gas investments in three regions: oil in the Northeast and Daqing oilfields, and natural gas in Sichuan Province – which together accounted for more than 56 percent of the 3.5 billion RMB (about 1.42 billion USD, current prices) of investment in oil and gas. As for the electricity sector, 9 billion RMB (about 3.66 billion USD, current prices) was invested during the third FYP. As a result, 10 hydropower and 28 coal-fired power plants were built in the Third Front area, with an installed capacity of 3.52 GW. More than 50 coalmines, 68 large and medium-sized power plants, and 8 oil and gas fields were established in the Third Front area, with 112 tons of coal production capacity, 18.7 GW of electricity capacity, 5.56 Mt of oil production capacity, and 5.4 billion cubic meters of gas production capacity added (CPC Literature Research Center, 1997c).

Though the Cultural Revolution led to a degree of chaos and an interruption of Chinese economic productivity, the government did not stop preparing FYPs. The third FYP was initiated in 1965, with 100 billion RMB (about 40.6 billion USD, current prices) invested in infrastructural development (National Planning Commission of China, 1964). After several changes and adjustments, the final plan assigned 85 billion RMB (about 34.5 billion USD, current prices) to infrastructure , including 33 billion RMB (about 13.4 billion USD, current prices) that went to the Third Front area. Of that 33 billion, the energy industry received 5.14 billion RMB (about 2.09 billion USD, current prices) spread across covering 66 projects (CPC Literature Research Center, 1997c). However, industrial production had been proceeding without state guidance since 1966, when the National Planning Commission and the National Economy Commission were temporarily shut down (Cong and Zhang, 1999).

This disorder and fragmentation had considerable impacts on Chinese energy supply. For example, the electricity generated at the end of 1967 was only 65 percent of what it was the year before, while only 76.3 and 81.6 percent of planned raw coal and crude oil production had been achieved, respectively (Cong and Zhang, 1999). The fourth and fifth FYP were proposed in 1970 and 1975, respectively (National Planning Commission of China, 1970, 1975), but were not followed.

Despite the failure to complete some years' production plans and the lack of enforcement for FYPs, actual levels of energy production during the Cultural Revolution remained relatively high. Oil production, for instance, was reported to have exceeded its target by 66 percent in 1970 (see Table 1) (NBSC, 2003). From 1965 to 1980, raw coal production went up from 232 Mt to 620 Mt. Moreover, crude oil reached a historical record of 105.95 Mt, about 10 times its level in 1965. Notwithstanding the turbulent decades, total primary energy production rose from 188.24 Mtce to 637.35 Mtce between 1966 and 1980. One remarkable change was the evolution of the energy mix. Coal's share in energy production dropped to 69.4 percent, the lowest share up to that point, while oil took a historical record share of 23.8 percent. Even when the industry lacked guidance from central state planners, local advocates prioritized and kept most energy and industrial facilities working (People's Daily, 1967). The resulting energy production mix in 1980 was the most diversified in China's history, even compared with that of today.

Table 1. Planned and actual energy production in the People's Republic of China, 1965 to 1980

	Raw Coal (Mt)		Crude Oil (Mt)		Electricity (TWh)	
	Planned	Actual	Planned	Actual	Planned	Actual
1965		232		11.31		67.6
1970	280~290	354	18.5	30.65	110	115.9
1975	400~430	482		77.06		195.8
1980	550~580	620	150	105.95	300	300.6

Source: China Statistical Yearbook 2003.

2.4 Reform (1979–2000)

After the Cultural Revolution ended in 1976, China experienced a leadership transition, and its new power structure pondered the country's future. After two years of discussion, the government decided to officially reform in late 1978, and the country stepped into a new phase of energy strategy.

After the Third Session of the 11th Central Committee of the CPC in late 1978, the government intensified its focus on economic development and began systematic reforms. The policy of "Opening

Up" attempted to morph the planned economy into a more market oriented one, and a market logic started to replace administrative instructions. In the energy industry, for example, energy production was no longer decided by government planners, but by market demand. Though the government would remain the most substantial player in the energy industry, plenty of non-state-owned capital began to flow into the sector. The energy market was increasingly diversified, which stimulated growth and competition. Meanwhile, with more private and local capital entering the energy industry, many groups of small coal mines were established.

Broader political and economic adjustments weakened the government's control and interventionist stance in the economy (Weingast, 1995). Restructuring in the late 1970s began by decentralizing jurisdiction over economic planning to local and provincial authorities, and practices intensified in the 1980s when more than 50% of the national budget was delegated to the provinces. During that decade, dependence on state-owned enterprises lessened and both households and firms gained more autonomy as the economy shifted from an agrarian model to a more diversified marketplace (Nee, 1992). The result was a transition economy characterized by the emergence of more competitive markets, partial privatization, and limited property rights. Though these reform efforts have been criticized as "partial" and "tentative," they have had the unintended consequence of eroding governmental power (Walder, 1995; Rawski, 1999). Moving towards the market system by necessity reduced state authority, at least to some extent.

Therefore, in the following several FYPs, electricity was to be dictated by a more market orientated set of policies focused on diversification. The seventh FYP proposed the general principles of China's energy policy, namely that future policies should focus on electricity, greatly develop coal-fired power, vigorously exploit hydropower, and gradually develop nuclear power (National Conference of the CPC, 1985). Importantly, the seventh FYP also stressed that China should develop new and renewable sources of energy—small hydropower, solar power, wind power, and geothermal power (Zhao, 1987). The eighth FYP witnessed another important milestone in China's energy history. Two nuclear power plants were put into operation in 1991 and 1994, respectively, and several nuclear power projects were placed into construction (Qin, 1999; Sovacool and Valentine 2010; 2012). The ninth FYP attached great importance on the development of coal-fired power and hydropower, strengthened the development of renewables, and restricted the development of small coal-fired power plants (the Fourth Session of the 8th National People's Congress of China, 1996).

This period also saw a shift in emphasis towards a "focusing strategy" that called for energy investments in energy-rich areas (Liu, 1995). This essentially reversed some of the equity impacts that had emerged as a result of the spatial distribution cemented during the earlier decades of socialist construction. In fact, this strategic change began in the sixth FYP, when the coal industry began to expand to Shanxi and Inner Mongolia. Meanwhile, the exploration of oil and gas expanded into the western region and the offshore oilfields. Efforts were also made to reduce the spatial disparity between energy resource distribution and centers of demand. In order to ease pressures related to the transport and logistics of distributing fuel, several railway projects were initiated under the eighth FYP, notably those supporting the energy industry in Central and Western China (the seventh meeting of the 13th Central Committee of the CPC, 1990).

Moreover, it was during this period that efforts were devoted to energy efficiency and energy conversation. Across the four FYPs within the "reform" phase, we counted 25 rules and acts, 27 types of design specifications, and almost 100 items related to standards about various aspects of efficiency in energy end use and demand, including financial support for more efficient electric appliances, rewards for energy conservation management and promotion, and demand-side management programs at electric utilities (see Table 2) (State Power Corporation, 2001).

Table 2. Major Energy Efficiency and Energy Conservation Rules and Regulations in the People's Republic of China

Year	Energy saving policies

1981	Establishing special financial funds for energy saving infrastructures construction and technological transformation with preferential interest rate
1986	Promulgating the Provisional Regulations on Energy conservation to train and encourage the adoption of energy saving technologies in production and livings
1987	Approving several provisions on further strengthening electricity conservation
1994-1995	Assigning special funds to support enterprises to transform fans and pumps
1996	Publishing China Energy Technology Policy
1997	Promulgating the Energy Conservation Law People's Republic of China
1998	Formulating several technical specifications of cogeneration development
1998	Establishing China Committee for Certification of Energy Conservation Product and China Certification Center for Energy Conservation Product, and formulating the Management Measures of China Energy Conservation Product Certification
2005	Specifying the focal points and measures of building a conservation-oriented society

Source: Compiled by the authors

Another distinct trend that emerged during this period of reform was an emphasis on access to electricity and modern forms of energy. Deng Xiaoping remarked that the 800 million peasants in China needed electricity, and argued that all kinds of energy sources should be developed, including thermal power, hydropower, nuclear, solar, biogas, tide and wind power, and the new and renewable energy could have a bright future with scientific progress (Research Group of Economic Incentives Policy for Renewable Energy Development, SETC, 1998). China also launched a very successful National Improved Stoves Program that disseminated cleaner cooking devices to rural homes in an effort to reduce deforestation and improve household energy security (Smith et al. 1993). In addition, several laws and regulations related to environmental protection were released in the 1980s. At the same time, the production of coal, oil, and natural gas increased constantly to meet the continuing escalations in residential, commercial, and industrial demand (Zhao, 1987).

From 1978 to 2000, China's energy production thus doubled from 627.7 Mtce to 1350 Mtce, mainly through coal production. However, the structure of the energy mix changed, because coal increased its share in the energy production mix slightly, while oil decreased by 6.6 percent. A drop of oil's share did not mean oil production declined. On the contrary, it increased by 56 percent, but not as fast as other sources. In the mid-1990s, China also became a net oil importer, and its dependence on imported oil rose constantly over the remainder of the period (National Bureau of Statistics of China, 1999). The share of natural gas, nuclear and renewable energy, though small, also steadily grew.

2.5 Contestation (2001– 2014)

During this relatively brief period, the Chinese economy expanded beyond even the expectations of its planners. More than 70 million new jobs emerged in the Chinese economy, and the country led the world in markets for automobiles, steel, cement, glass, housing, power plants, renewable energy, highways, rail systems, and airports. Its economy grew so fast that analysts anticipated it ballooning from $6 trillion worth of GDP in 2010 to $9 trillion by 2015; from 1990 to 2008, for example, energy use in China grew a staggering 146 percent (Schneider et al., 2010). Since the ninth FYP (1996-2000), the central government's energy policy lost some of its focus, and it entered an era of what we term contestation. As we explain in this section, part of this contestation related to a growing expansion of formerly alternative sources of energy such as renewable electricity and nuclear fission; part to a growing import dependence; and part to the environmental threats from energy such as ambient air pollution and greenhouse gas emissions.

To restrict the overproduction of coal, and protect resources and the environment, the central government decided in the late 1990s to shut down illegal coal mines and restrict small ones (State Council of China, 1998). In order to stimulate the development of renewable energy as a substitute, China set up goals and plans, enacted several laws and acts, and provided economic incentives. In particular, the Renewable Energy Law was passed in 2005. From 2004 to 2014, China's investment in renewables increased from 3 to 83.3 billion USD, and its share of global investment grew rapidly from 6.7 percent to more than 30 percent (Renewable Energy Policy Network for the 21st Century, 2015). By the end of 2014, China was home to approximately one quarter of the world's renewable power capacity, with a capacity of 153 GW. Furthermore, renewables accounted for more than 20 percent of China's total generating capacity (Renewable Energy Policy Network for the 21st Century, 2015).

However, even these gains and the so-called "energy scramble" strategy (Hodd, 2008), in which China pursued multiple energy fuels and technological platforms, were not able to offset even greater increases in demand and a growing dependence on imported fuels. In aggregate, from 2001 to 2014 China's primary energy consumption increased by 150 percent, reaching 3840 Mtce, or more than one fifth of the world's total consumption. However, it only produced 3600 Mtce in 2014 (National Bureau of Statistics of China, 2014), which meant China had to import at least 240 Mtce of energy that year (see Table 3). In 2014, almost 60 percent of its oil demand depended on imports. In fact, China is unlikely to expand its crude oil outputs significantly in the near future (Leung, 2011), and some estimates suggest that China's oil dependence will rise to 60–80 percent by 2020 (Downs, 2006). Coal had always been a strategic export; however, since 2009, China has also become a net coal importer.

Table 3: Energy import and export dependency in the People's Republic of China, 1995 to 2013

Year	Total Primary Energy (Mtce)		Coal (Mt)		Oil (Mt)	
	Import	Export	Import	Export	Import	Export
1995	54.6	67.8	1.6	28.6	36.7	24.5
1996	68.4	75.3	3.2	36.5	45.4	27.0

1997	99.6	76.6	2.0	30.7	67.9	28.2
1998	84.7	71.5	1.6	32.3	57.4	23.3
1999	95.1	64.8	1.7	37.4	64.8	16.4
2000	143.3	90.3	2.2	55.1	97.5	21.7
2001	134.7	111.5	2.7	90.1	91.2	20.5
2002	157.7	110.2	11.3	83.9	102.7	21.4
2003	200.5	129.9	11.1	94.0	172.9	22.4
2004	265.9	116.5	18.6	86.7	171.6	28.9
2005	269.5	114.5	26.2	71.7	171.6	28.9
2006	311.7	109.3	38.1	63.3	194.5	26.3
2007	349.0	103.0	51.0	53.2	211.4	26.6
2008	367.6	99.6	40.3	45.4	230.2	29.5
2009	473.1	84.4	125.8	22.4	256.4	39.2
2010	557.4	88.5	163.1	19.1	294.4	40.8
2011	622.6	84.5	182.1	14.7	315.9	41.2
2012	666.0	73.8	288.4	9.3	330.9	38.8
2013	734.2	80.5	327.0	7.5	378.2	32.2
2014			291.2	5.74	372.8	26.2

Source: Authors compilation of National Bureau of Statistics of China data. Note: Mtce = million tons of coal equivalent. Mt = million tons.

Over this period, China continued to direct massive investments towards coal. Between 2001 to 2010 more than three-quarters of all coal-fired power plants world-wide were built in China, enabling coal to contribute to about 80 percent of Chinese electricity generation in 2010, the same year the Chinese coal sector employed 7.8 million people and produced about 40 percent of the world's coal (Sovacool et al., 2011). Environmental degradation, air pollution, and climate change therefore became important social and strategic concerns in this period. In the 2000s, for instance, the World Health Organization estimated that 517,700 people died annually because of outdoor air pollution in the entire Asia Pacific region, but that more than half of these deaths (275,600) occurred in China (World Health Organization, 2007). Chinese economists calculated the monetary damage from this pollution at a staggering $63 to $272 billion or as much as 3.3 to 7.0 percent of national GDP (Deng, 2006; McMichael, 2007). In 2008, it was estimated that only one percent of China's 560 million city dwellers breathed air considered safe by the European Union (World Bank, 2007; Andrews, 2008). Text Box 1 provides a brief history of air pollution control in China.

Text Box 1: History of Chinese Air Pollution Policy

The problem of air pollution began to receive political attention in the 1970s, when a series of severe incidents culminated in negative global publicity (Liu, 2013). During the 1980s and 1990s, the rapidly increasing economy had brought about the explosive growth of coal consumption, which led to large amounts of sulfur dioxide emissions and acid rain across the country, and caused great environmental and economic damage (Shao et al, 2006). By then, the central government realized the seriousness of air pollution problems, and paid more attention on air pollution control, even drawing up the Law of Atmospheric Pollution Prevention (Hao et al, 2014). Reform of central government institutions followed, and a series of industrial ministries, such as the Ministry of Electricity Industry, Ministry of Coal Industry and Ministry of Metallurgical Industry, were abolished, and more authority was given to the State Environmental Protection Administration (SEPA) (Jahiel, 1998). The 21st century saw the SEPA promoted to ministerial status alongside the rise in the "Scientific Outlook on Development" rhetoric, that included sustainable development as a core objective (Geall and Ely, 2015) Environmental policy priorities including industrial dust, nitrogen oxides and PM10 have been targeted, and total pollutant emissions have gradually been controlled (Hao et al, 2014). Following conflicts over air quality monitoring results by China and foreign institutions, PM2.5 readings came to be a significant source of public dissatisfaction, and the focus has been extended to air quality improvement (Hao, et al., 2016), further strengthening the political objective of cutting fossil energy (in particular coal).

The Twelfth FYP, adopted by the Chinese government in March 2011, brought environmental and climate-oriented concerns to the forefront of national policy (Xinhua News Service, 2011; NRDC Switchboard, 2011). In order to meet its international obligations to reduce carbon emissions, the Chinese government promised that by 2020 it would cut its carbon intensity by 40 to 45 percent compared with 2005 levels and increase the share of non-fossil fuels in total primary energy supply to 15 percent after the Copenhagen Climate Summit in 2009 (Zhang, 2011). Other targets included:

- Decreasing energy intensity (energy consumed per unit GDP) by 16% by 2015.
- Increasing share of non-fossil energy in total energy mix from current 8.3% to 11.4% by 2015.
- Increasing R&D expenditures on cleaner forms of energy supply from 1.8% GDP to 2.2% GDP.
- Reducing nitrogen oxide and ammonia nitrogen pollution, linked to industrial heavy metal pollution, by 10% by 2015.

These four requirements were binding targets, and therefore provincial and local officials, and the heads of state-owned enterprises, were (at least in principle) evaluated, and penalized or promoted, based on how well they were enforced (NRDC Switchboard, 2011).

However, over the period of "contestation", multiple government objectives have led to a number of inconsistencies and failures of implementation and enforcement. Rapid economic growth, particularly after China entered the World Trade Organization, contributed to a 14 percent average annual increase in energy demand from 2000 to 2005 (Kahrl and Roland-Holst, 2008). These increases in demand resulted in frequent shortages of electricity and blackouts. In the North China Grid, for example, 12 provinces, municipalities, and autonomies had to implement rolling blackouts in 2002, a number that rose to 22 in 2003, 24 in 2004, 26 in 2005, 19 in 2008, and 24 in 2011 (Ni, 2006; China Electric Power Yearbook, 2009 and 2012).

It may come as no surprise then that these trends culminated in contestation over control of Chinese national energy planning and strategy, with tensions between institutional actors. Regional government authorities gained more sway over economic and social development within their municipalities, prompting civil groups, e.g. China New Energy Chamber of Commerce, and China Clean Energy Industry Association, to influence energy planning and siting decisions (Zeng, 2014; Pan and Lv, 2015). Structurally, energy industry reforms further shifted power, requisite knowledge and resources away from central government planners to state-owned energy companies. With local governments and foreign investors gaining more control over the energy investment flows and planning, some investors even saw a trend in China towards a US-style "competitive market model" (Cudahy, 2008).

As a consequence, disagreements solidified over approaches to energy promotion and technology development. These disagreements have been accentuated by a proliferation of players participating vociferously in policy discussions including newly corporatized large energy companies, universities, think tanks, and the media. The scientific network in favor of nuclear power alone—one mere subsector—is now said to include over 300 different enterprises. And although not always directed at energy systems or strategy specifically, the number of officially recorded environmental protests throughout China has risen from 10,000 in 1994 to 74,000 in 2004 and 97,000 in 2005 (Zackey, 2007). Subsequently, pronounced disagreements often percolate to the surface as advocates of particular energy systems, such as nuclear power or energy efficiency, clash with pro-coal advocates (Xu, 2008; Wang, 2009; Ma et al., 2009; Sovacool and Valentine 2010).

Essentially, the "contestation" phase reflects the move from command-and-control towards more market-oriented approaches, with the mixed motivations of jobs and growth, climate change and air pollution (Sovacool and Saunders 2014). In particular, whilst earlier phases saw cadre evaluations linked to GDP growth, the contestation phase led to the more recent adoption of additional environmentally-related performance indicators (Geall and Ely 2016), paving the way for the "transition" phase we identify next.

Contestation has also been evident in the process of marketization and the interactions between provinces and the centre. "Energy revolution" has been an important part of China's energy strategy, and energy market reform is an essential element (Cherni and Kentish, 2007). However, there are presently five energy-related laws in China, some of which have operated for decades without any revisions, creating conflicting pressures towards market reform, some favoring monopoly structures, others more competitive market structures (Xiao, 2010). Indeed a series of administrative regulations have substituted for energy laws. For example, China's energy intensity goal under the 12th FYP is disaggregated at the level of each province. Provincial leaders pushed local energy consumers to control their energy consumption, even in some cases abruptly cutting power supplies, against market rules (Han, 2015). In another example, the State Council promulgated a series of regulations to promote reform in the electricity system, separating and reorganizing power generation and electricity grid companies and even establishing a more competitive tariff mechanism to create more market competition. However, such reforms have been considered by many a failure (Han, 2015).

2.6 Transition (2015-present)

The final, and ongoing phase, represents a "transition" away from the fossil (in particular coal) centered energy system of the previous decades – one in which the state continues to play a core role, but in which its agency is tempered by market forces, provincial government and non-government actors. Stepping into the 2010s, China's economic growth abated, and stroked a 25-year low of 6.9 percent growth in 2015, with a target of 6.5 percent for 2016 (Shaffer, 2016). China's coal production and consumption has been declining from 2014 (Yeo, 2016), but the slowed growth of the economy has forced China to further reform its economic structure, importantly cutting excessive production capacity, especially that in coal, cement and steel.

More than 500 million tons of coal capacity was eliminated during the 12th FYP (Bie, 2016). At the outset of the 13th FYP in 2016, the State Council promulgated the regulations on resolving the overcapacity of coal industry, which said that China would eliminate as much as 500 million tons of coal capacity, and consolidate another 500 million tons of capacity in three to five years (Bloomberg News, 2016). In order to do this, both coal-producing provinces and enterprises set targets to eliminate overcapacity (Bie, 2016). Incomplete market reforms have, however, failed to lead to the elimination of overcapacity, and conflict between central and provincial government has weakened the effect of administrative instructions sent from Beijing to the provinces.

Beyond the reduction in coal capacity, another key trend has been rapidly increasing investment in renewable energy. Through a raft of policies, financial incentives and direct government support, China has become the world leader in terms of investment and installed capacity (Renewable Energy Policy Network for the 21st Century, 2015). Problems such as curtailment (whereby policies drive installation of renewable energy whilst neglecting its connection to the grid), an inability of the outdated Chinese grid infrastructure, and misadjusted pricing systems for excess supply from variable renewable production remain (Liu, et al., 2015; He, et al., 2015). However, the steady increase in renewables and decrease in coal means that the country continues to move towards its target of peaking its carbon dioxide emissions by the year 2030 (Harvey, 2016). Whilst the central government continues to play a role in a still reforming economy (Chu and Song, 2015), it is clear that much of the drive for decarbonisation and renewable energy investment also comes from government and non-government actors in some (but by no means all) provinces (Chen and Lees, 2016). The current system remains in a state of flux.

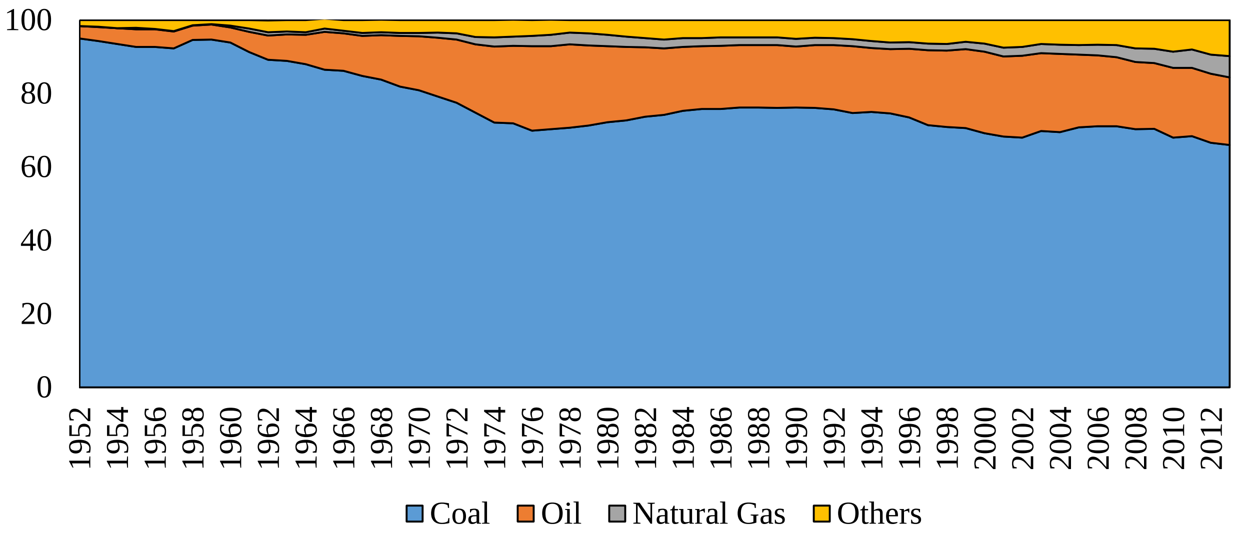
3. Contours of China's energy strategy: Diversity, Security, and Governance

This section situates the previous historical discussion of six phases with significant, recurring themes. It presents the evolution of several current traits of current Chinese energy strategy, some of them positive, and some negative. Three include embracing diversity (positive) and declining energy intensity (positive) alongside growing dependence on imports (negative), fragmented governance (negative), and poor environmental literacy (negative).

3.1 Embracing diversity

A diversified energy mix had always been a salient strategic goal for Chinese planners. However, due to China's energy endowment, rich in coal, poor in oil, and short in gas, China's energy mix remains dominated by coal. That said, Figure 3 does point towards an expanding level of diversification and the expansion of oil, natural gas, and other alternative sources of energy. During the time of the planned-economy through the emergence, socialist construction and turbulence phases (1949–1978), coal's share showed an obvious decline, dropping from 95 percent to 70 percent. On the other hand, the oil industry witnessed unprecedented growth, especially after the late 1960s, when the Karamay and Daqing Oilfields were discovered. Other energy sources, mainly hydropower, have kept a share of 2 to 3 percent. After the late 1970s, China began to seriously add natural gas to the national energy mix. Lastly, other energy sources, including renewables and nuclear energy, took an increasing large share, even reaching 10 percent by 2013.

Figure 3: Energy consumption by source in the People's Republic of China, 1952 to 2013



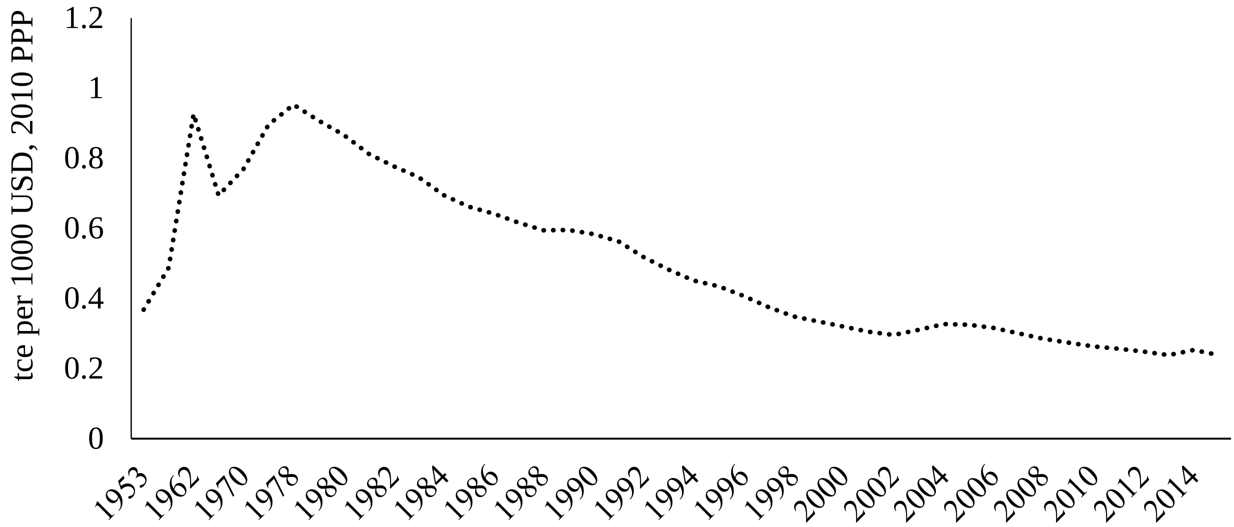
Source: Compiled by the authors

Even renewable sources of energy, many of them smaller in scale, have had a prominent albeit not always substantial role in national energy production. At the beginning of the first FYP, the government invested in several small- and middle-sized hydropower plants, and tried to build a few large ones to prepare for the future massive construction. Ultimately, eight small- and middle-sized hydropower plants were constructed, as well as a large one. During the next years, hydropower plants were continually deployed all over the country, especially during the Great Leap Forward and the Third Front Movement. In the 1990s, planners began to notice other sources of renewables, when the government enacted a series of supporting policies to encourage the development of renewables. In 2005, the Renewable Energy Law of the People's Republic of China was promulgated. After that, the Long-term Development Plan of Renewable Energy in China was implemented in 2007, which targeted not only hydropower but also biofuels, wind power, and solar power, and other sources. In 2014, China's investment in renewables reached over 83 billion USD, which is the highest renewable investment that year, higher than that of the whole of Europe (Renewable Energy Policy Network for the 21st Century, 2015). From policy to practice, China has made noteworthy progress in its quest for diversification.

3.2 Declining energy intensity

A second key theme has been enhanced national energy efficiency. The usual proxy for measuring this is termed "energy intensity," and it refers to the amount of energy needed to produce one unit of GDP. Figure 4 identifies several trajectories in the improvement of energy intensity.

Figure 4: Energy intensity in the People's Republic of China, 1952 to 2013



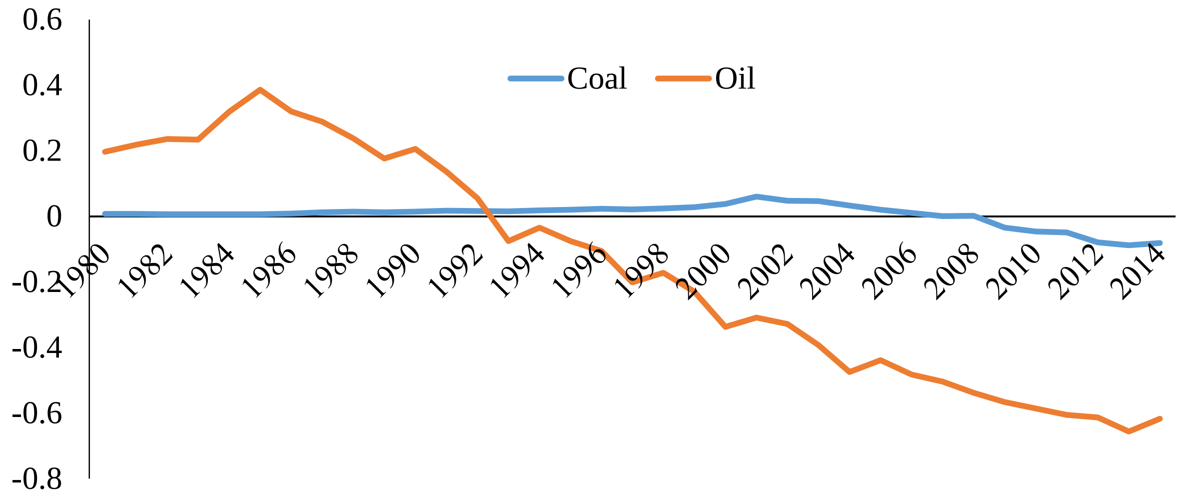
Source: Authors' calculation based on data from China Statistical Yearbook.

At the beginning, during the periods of emergence and socialist construction, energy intensity of production was relatively high (i.e., efficiency was low), with a gradual improvement during the first FYP. After 1957, due to the heavy-industry-focused policy and the Great Leap Forward, energy intensity trends worsened. After a series of difficulties, the government adjusted its economic structure, thus the energy intensity dropped suddenly from 1962 to 1965. With the Third Front Movement and the Cultural Revolution coming one after another, intensive investment went to infrastructure establishment, which pushed the energy intensity to another historical high level. With the economic reform since the late 1970s, China witnessed an obvious and steady decline in energy intensity. From 2003 onwards, the notion of sustainable development became more prevalent and accepted among state planners (Geall and Ely, 2015), especially when the "Scientific Outlook on Development" was proposed (the Third Session of the 16th Central Committee of the CPC, 2003). From then on, the government put great effort into improving energy efficiency, and it promised that by 2020 China would cut its carbon intensity by 40 to 45 percent compared level of 2005.

3.3 Growing import dependence

Not all trends, of course, have been positive. Under thirty years of a heavily planned economy, China, mostly closed to the world, was self-sufficient, meeting all of its net energy needs independently. After passing through the phases of socialist construction and turbulence, however, China came to depend more on international energy markets and imported energy fuels. China has had to rely on external supply to sustain its national energy balance since the 2000s, and its energy dependence reached 15 percent by 2014. Coal, long thought to be practically inexhaustible and widely available within China, also saw its reign of self-sufficient production and consumption end in 2009, when China became a net importer (NBSC, 2010). China's coal dependence has kept climbing, reaching a record 65 percent in 2013, as shown in Figure 5.

Figure 5: Coal and oil independence in the People's Republic of China, 1980 to 2014



Source: Compiled by the authors

China was a net oil exporter for more than a decade in the 1970s and 1980s. Yet after 1993, China gradually turned into an oil importer, and oil dependence peaked at more than 60 percent in the 2010s.

3.4 Fragmented energy governance

Despite moderately clear roles for local, provincial, and national jurisdictions over energy, a degree of fragmentation has persisted, and actors at times duplicate and contradict each other. Put another way, for most of its history, there has been no such thing as a unified national Chinese energy policy or strategy. Instead, there are many different energy policies, enacted at different times by different actors for different reasons.

The result is a labyrinthine and complicated governance structure, an energy related bureaucracy becoming increasingly contradictory. The responsibility for energy pricing, permitting and approval of projects, oversight of state energy companies, and adjustment of electricity rates are spread across many ministries and agencies, to say nothing of the jurisdiction for environmental, health, transport, and urban policy. Moreover, most agencies lack the capacity and the authority to carry out their duties effectively. Put another way, no overarching theme or principle therefore guides Chinese planners, and the country instead appears wedded to a portfolio approach or "all of the above" strategy that pushes a variety of technologies and systems, even those that tradeoff with each other, to appease as many diverse stakeholders as possible (Green and Kryman, 2014).

One positive interpretation for this fragmentation is decentralization. In a way, the convoluted strategy enables provinces to experiment with different options, acting like the "laboratories of democracy" that the individual states do in the U.S., then choosing the one that seems to work the best. For instance, Zhang et al. (2017) assessed the energy security performance of Chinese provinces on a series of historical metrics, and noted that the collection of policies embraced by the Middle Reaches of the Yellow River and the Northwest seemed to be the most effective at meeting policy goals and improving security, whereas those in the Middle Reaches of the Yangtze River and the Northeast were not. Florini and her colleagues also argue that China can be seen as "a vast laboratory where different social, political, and economic policies are tested and compete for the attention of the leadership" (Florini et al., 2012). Another study affirmed and even praised this aspect of Chinese energy strategy by calling it "pragmatically flexible" (Kong, 2011). A negative interpretation is lack of consistency, with additional transaction costs and pressures for investors trying to navigate the country's complex governance architecture (Andrews-Speed, 2012).

3.5 Poor environmental literacy

A final pejorative theme that has come alongside growing fragmentation of energy governance is relatively low levels of energy literacy, the knowledge that consumers have about energy technology and use (Sovacool and Blyth, 2015). One comprehensive study on Chinese environmental attitudes, for example, revealed that knowledge of ecology and environmental issues was limited to those well-educated and living outside major urban areas (Harris, 2006). It found that for most Chinese, environmental issues such as sanitation, health, water, and air pollution were issues of growing concern but nuclear power was not. It confirmed that, given China's economic development needs, most Chinese prioritise poverty alleviation, economic development and growth, and wealth creation, aspiring to achieve Deng Xiaoping's "glory of getting rich". As the study concluded, "how human behavior affects the environment is poorly understood, and normally there is a complete absence of knowledge about global environmental issues such as stratospheric ozone depletion and climate change. People often do not realize that their own actions are causing environmental harm" (Chan, 1999). A typical example is the excessive application of fertilizers in China's agriculture, which most people fail to realize causes soil deterioration and water pollution (Zhu et al., 2005; Ju et al., 2007).

4. Conclusions and implications

For more than sixty years since the foundation of the PRC, China's energy strategy has experienced a transformation from a traditional planned economy to a more market oriented economy. China has been affected by national political and economic strategy, the physical or geological existence of energy resources, alterations and preferences in demand for energy, and social factors associated with pollution and climate change. Several conclusions can be drawn.

The first, a point we are not the first to make, is that energy trends in China are complex and at times contradictory. One set of current trends promotes environmentally sustainable economic development through notions of energy efficiency, frugality, and renewable energy resources.

Another overwhelmingly depends on polluting and wasteful nonrenewable energy sources to drive economic growth. In the current (transition) phase, these are exacerbated by the challenges of overcapacity, market reform and central-provincial dynamics. One overarching lesson from China's energy history is that the twin goals of sustainability, underpinned by clean energy, and economic development, underpinned by dirty energy, are inconsistent, and that when it comes down to it, economic development—a logic or rationale of industrial production—has trumped environmental sustainability in importance. However, given the alignment of multiple drivers against coal (in particular) and oil, the transition phase may shift these priorities in favor of sustainability, at least in the longer term.

Second, however, is a stark lesson: domestic energy trends and geopolitical relationships can change significantly in a matter of a few decades. Domestically, the emergent years of Chinese energy strategy focused on coal as a feedstock and steelmaking as a strategic sector. Though there were specific energy governance institutions, long-range plans for energy development and scientific management were still needed. During the period of economic reform, administrative interference weakened, yet market tools failed to deliver as hoped, leading to further reform. Globally, before the 1990s, China was entirely self-sufficient in its energy economy and it moved away from the influence of international energy markets, especially given the effect of several wars in the Middle East and the oil embargoes of the 1970s. Even after the 1990s, China maintained an energy supply that was 90 percent self-sufficient, but such an advantage has deteriorated sharply over the past decade.

We also see that the country's energy planning has been marked by tradeoffs. As it has come to embrace energy diversity through renewable sources of energy and sought to improve its national energy efficiency by lowering energy intensity of production, it has come to grow more dependent on imported fuels and has seen an increasing fragmentation of energy planning and governance activities. Ultimately, the world's largest energy user and greenhouse gas emitter is adhering to an energy strategy that represents more a bundle of technologies juxtaposed together than any comprehensive and coherent energy vision. The result will invariably be more fragmentation, inconsistency, tension, and countervailing trends relating to energy, not less. Market reforms, changing governance structures and the increased importance of new actors may further complicate the future energy strategy. Under these changing circumstances, a historical awareness of how the energy system has emerged is ever more vital.

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