IGES Discussion Paper October, 2019

The Current Status and Prospects for Coal Industry Transition in China

Xianbing Liu, Zhen Jin, Kentaro Tamura
Climate and Energy Area
Institute for Global Environmental Strategies (IGES), Japan

Key messages:

- This paper provides the background information on coal industry transition occurred recently in China, and shows prospects for better transition management with a focus on the employment.
- The share of coal in overall energy consumption was stable at around 70% for many years in China, but has been on a decreasing trend since 2010, and fell below 60% for the first time in 2018. Meanwhile, China's coal production experienced a sharp increase during 2000 and 2010, and has been stable since then. China is also the world's largest coal importer since 2011.
- An overview of various studies forecasting China's coal consumption indicates that the country's coal-dominated energy mix has to change fundamentally to be consistent with the temperature goals of the Paris Agreement.
- The great efforts in eliminating the overcapacity have resulted in significant unemployment in China's coal industry recently. The continuous improvement of mining efficiency and a reduction in coal consumption and production is likely to lead to further shrinking of employment in this sector.
- There is no one-size-fits-all solution and various policy measures have been taken for smooth diversion and settlement of the affected coal workers. Good practices that adapt to local conditions have been confirmed in certain places.
- A comprehensive policy package, i.e., the adjustment of industrial structure, financial support from the government, improvement of social security system and skill training, is suggested for managing the coal industry transition in China from a longer term perspective.

1. Introduction

Achieving ambitious mitigation of greenhouse gases (GHG) emissions in line with the goals of the Paris Agreement requires the prompt shift away from coal in the primary energy mix. For this purpose, recent studies indicate that phasing out coal must be done no later than 2030 in developed countries and no later than 2050 in the rest of the world (Climate Analytics, 2016). In this context, the phase-out of coal in China, the largest coal producer and consumer globally, is absolutely critical. However, such a phase-out would also be extremely difficult since coal has been dominating the country's energy supply and consumption for many years. The fundamental transition of coal industry is likely to bring significant consequences that will affect various stakeholders, particularly coal miners, local communities and governments in areas with a high reliance on the coal economy, as well as anyone holding of coal-related assets. Therefore, it is crucial to examine the potential impacts of coal industry transition in China from a comprehensive perspective and seek pragmatic countermeasures to overcome the related challenges.

Aiming to assist in the discussions of this complex issue and facilitate the mutual sharing and learning of experiences, this paper provides some background information on coal industry transition that has occurred recently in China, and shows prospects for better transition management with a focus on employment. Using statistical data and scenario analysis results provided in existing literature, changes in coal consumption, production and international trade in China so far, and the future consumption trajectory of coal are figured out quantitatively. The paper then identifies the impact of overcapacity elimination on employment in this industry in recent years and highlights further employment reduction due to declining consumption and improved mining efficiency in the long run. The difficulties for the phase-out of overcapacity in coal production, as well as policy measures and good practices to deal with employment loss are described in terms of policy suggestions in general. Besides second-hand data gathered through literature review, visits and interviews with several Chinese experts from coal-related industries were carried out to gather additional information and hear their insights.

This discussion paper consists of the following sections. Section 2 illustrates the historical change and current status of coal consumption, production and international trade of China. Applying prediction results from several mainstream studies, Section 3 shows the future trend of China's coal consumption until mid-century under scenarios in line with the current NDC target and the global 2℃ and 1.5℃ targets. Section 4 describes the historical changes and future estimations regarding employment in China's coal industry, and reviews the structural adjustment of the industry as the main reason for such changes in employment. Referring to the available literature, Section 5 explains the difficulties in the transition of the coal industry, including phasing out production overcapacity and settlement of those workers who lost their jobs due to the closure of coal mines. Policy measures and certain good practices are also listed in this section. Lastly, section 6 gives a conclusion and some recommendations.

2. Changes in China's coal consumption and production

2.1 Changes in coal consumption in China

Figure 1 depicts changes in energy consumption in total and changes for coal consumption in China between 1978 and 2017. The total energy use was only about 0.57 billion tce (ton of standard coal equivalent, 1 tce equals to 1.4 tons of physical coal) in 1978. This amount gradually increased to 1.47 billion tce in 2000, then quickly grew to over 4.0 billion tce in 2012. In more recent years, the growth in total energy use has declined along with the slowdown in economic growth, structural transformation of industry and improved energy efficiency. Total energy consumption is predicted to increase by around 2.5% annually during the current 13th five-year plan (FYP) period (2016-2020) (NDRC and NEA, 2016a). The latest statistics confirms that China's total energy use was 4.36 and 4.49 billion tce in 2016 and 2017, increases of 1.4% and 3.0% from the previous year, respectively (NBSC, 2018).

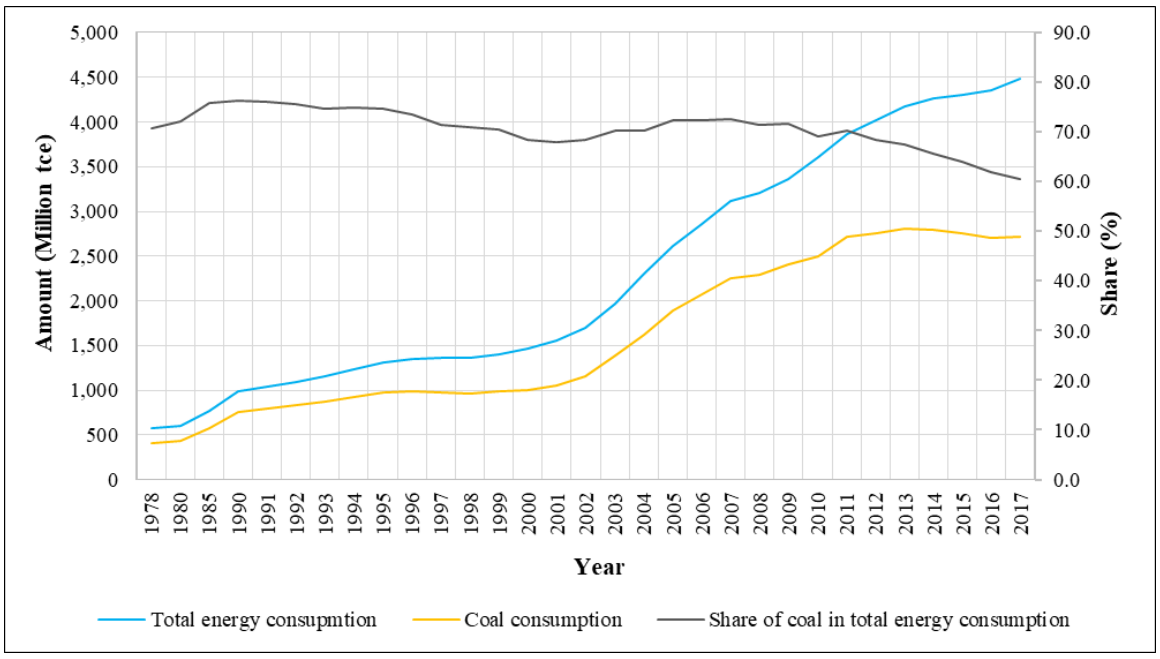

Figure 1: Changes in total energy and coal consumption in China (1978-2017).

The consumption of coal in China showed a similar trend to that of total energy use until around 2010. Coal consumption was about 0.4 billion tce in 1978 and increased to 1.0 billion tce in 2000, then rapidly grew to 2.75 billion tce in 2012. In contrast with the slower but still growing consumption of total energy, the use of coal in 2013 reached about 2.81 billion tce before plateauing. Coal consumption of China stopped growing in 2014 for the first time and followed a slightly decreasing trend from then on (Qi et al., 2016). Specifically, coal consumption fell by 0.6%, 1.5% and 1.8% between 2014 and 2016, as compared to each of the previous years (NBSC, 2018). The reduction of coal consumption in China may be a combined effect of several factors, including a slowdown in economic growth and restructuring of the economy (also known as the 'new normal'), efforts to improve air quality and actions against climate change (Qi et al., 2016; Tang et al., 2018).

Figure 1 shows that coal obviously dominates energy use in China. The share of coal in total energy consumption was stable at around 70% until around 2010, and then appears to be on a gradually

decreasing trend. In practical terms, China has been making efforts to improve its energy structure by reducing the share of coal. For the first time, NDRC and NEA (2016a) set a mandatory target to reduce the share of coal in total energy consumption to no more than 58% by 2020, from a share of 64% in 2015. This will lead to a significant shift in China's energy structure. Correspondingly, non-fossil energy will contribute to around 15% of primary energy use, and the share of natural gas will increase to around 10% by 2020 (NDRC and NEA, 2016b). Through various countermeasures, China's energy structure has shown quite an improvement in recent years. The share of coal in total energy consumption fell to 62.0% in 2016, 60.4% in 2017, and below 60% for the first time in 2018 (Ruan, 2019). Oil, natural gas and others (non-fossil primary energy) individually accounted for 18.8%, 7.0% and 13.8% in 2017 (NBSC, 2018). It will certainly be possible for China to fulfil the target of coal share reduction by 2020, as it has done with energy and carbon intensity targets in the past. Reducing the share of coal even lower to 55% and coal consumption to 3.5 billion physical tons (2.5 billion tce) by 2020 would be feasible with more aggressive energy efficiency and coal replacement policies (Lin, 2017).

2.2 Changes in coal used for power generation in China

The installed capacity of power generation by the type of energy sources and the share of thermal power during 2000 and 2017 in China are depicted in Figure 2.

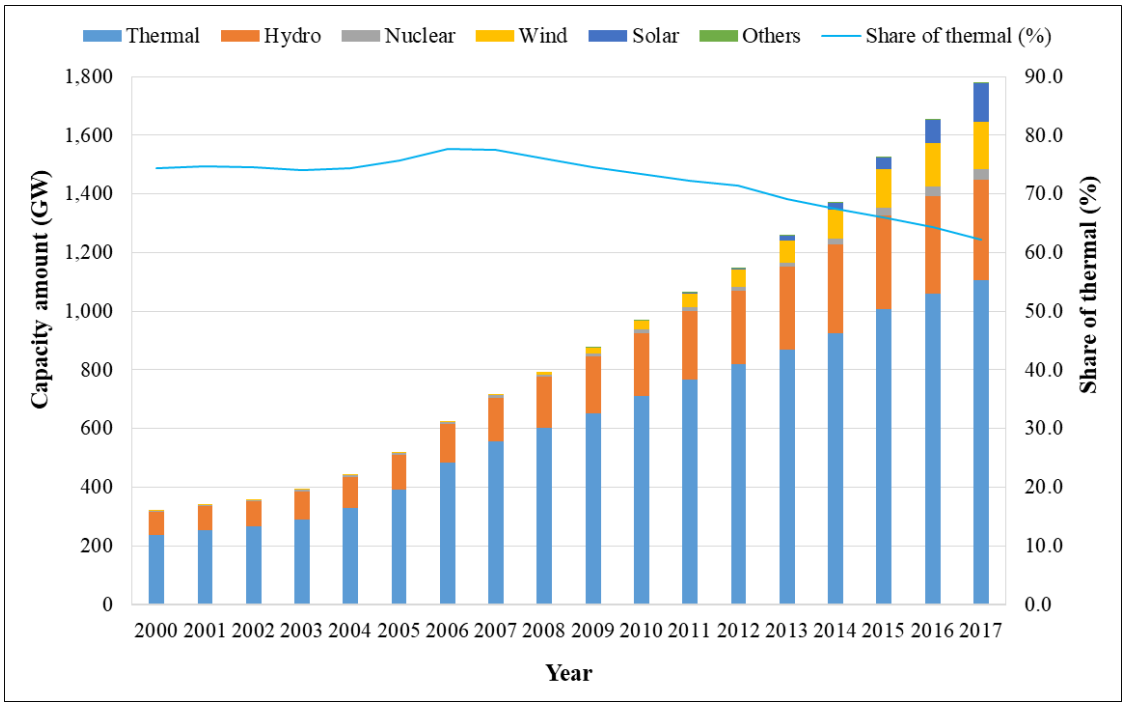

Figure 2: Installed power generation capacity and the share of thermal power in China (2000-2017).

Power generation capacity in China has been increasing steadily to sustain the country's growing electricity demand. As a result, the overall capacity reached 1,777 GW in 2017. It is well known that China became the world largest manufacturer of solar cells and wind turbines within one decade since 2005. Its solar PV production contributes to around half of the global total. Four Chinese wind turbine companies are among the top 10 manufacturers in the world. Meanwhile, wind and solar power

installation experienced a rapid growth, and their capacity increased to 163.67 GW and 130.25 GW by 2017, respectively sharing 9.2% and 7.3% of the total power generation capacity (NBSC, 2018). Along with the fast development of renewable energy, the share of thermal power generation capacity has been decreasing since 2007, falling to 62.2% in 2017. Out of this, the capacity of coal-fired power generators was 980 GW in 2017, with a share of 55.1% of the total (NBSC, 2018).

According to NDRC and NEA (2016a), the installed capacity of coal-fired power generation is due to be capped at 1,100 GW by 2020 and its share will decrease to about 55%. To achieve this target, a total of 101 coal-fired power generation projects, which have been approved by national and local governments, were suspended as of January, 2017. The power generation capacity of these projects comes to 102.45 GW, with a total investment of 430 billion Yuan[1]. Furthermore, there has been a significant improvement in the composition of coal-fired power generators. By the end of 2017, the overall capacity of operating coal-fired units with a scale of 600 MW and above reached 460 GW, accounting for about 47% of the total capacity of coal-fired power generators. Out of these, the number of Ultra Super Critical (USC) units with a scale of 1,000 MW reached 101.

Figure 3 depicts the total power generation, the amount generated by thermal and coal-fired power units and their share of overall generation.

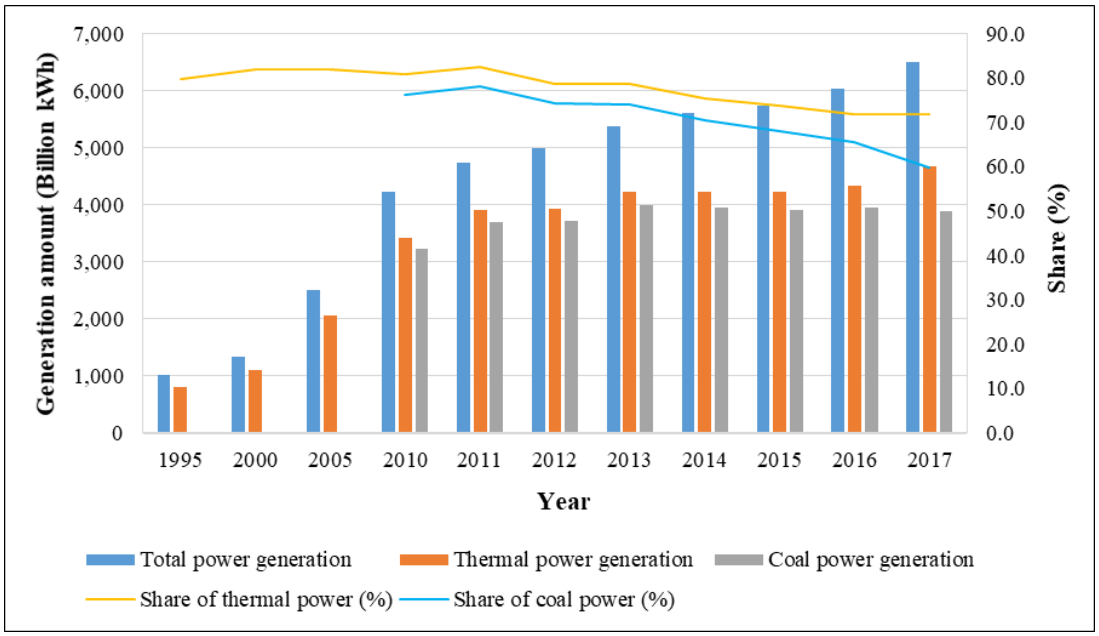

Figure 3: China's power generation and the share of thermal and coal power (1995-2017).

China generated a total of 6,495 TWh (terawatt hours) of electricity in 2017, an increase of 5.7% from 2016. Coal-fired power generation represented the largest portion, amounting to 3,880 TWh or 59.7% of the total, and a 1.7% decrease from the previous year. The second largest electricity source was hydropower, which generated about 1,160 TWh for a 18.2% share of total generation. Wind power generation grew to 310

[1] Source: http://www.chinapower.com.cn/focus/20170118/829.html. (In Chinese, accessed on February 6, 2018)

TWh (4.8%); nuclear power grew to 250 TWh (3.9%); and, solar power reached 120 TWh (1.8%). Because of the increasing generation from non-fossil energy, such as wind, solar and nuclear power, the shares of thermal and coal-fired power in total have shown a decreasing trend since 2011.

Coal-fired power plants used 1.95 billion physical tons of coal in 2017, accounting for 51.3% of a total of 3.79 billion tons of coal used in the same year (Huang, 2018). Along with rapid changes in power generation structure, it is necessary to limit coal-fired power plants to a more reasonable level. According to Lin (2017), coal-fired power generation capacity of China should be capped at 990 GW by 2020 in order to avoid the risk of stranded assets and keep the power sector on a greener track.

2.3 Domestic production and international trade of coal in China

As shown in Figure 4, the domestic production of raw coal was slightly over 1.0 billion tons in 1990. This amount increased to nearly 1.4 billion tons by 2000, and then quickly climbed to 2.4 billion tons in 2005 and 3.4 billion tons in 2010. Coal production has been stable since 2010 and reached a peak at 3.87 billion tons in 2014. Coal production in 2017 was 3.52 billion tons, which was a 92.8% share of the same year's domestic consumption and the first indication of a recovery since production peaked in 2014.

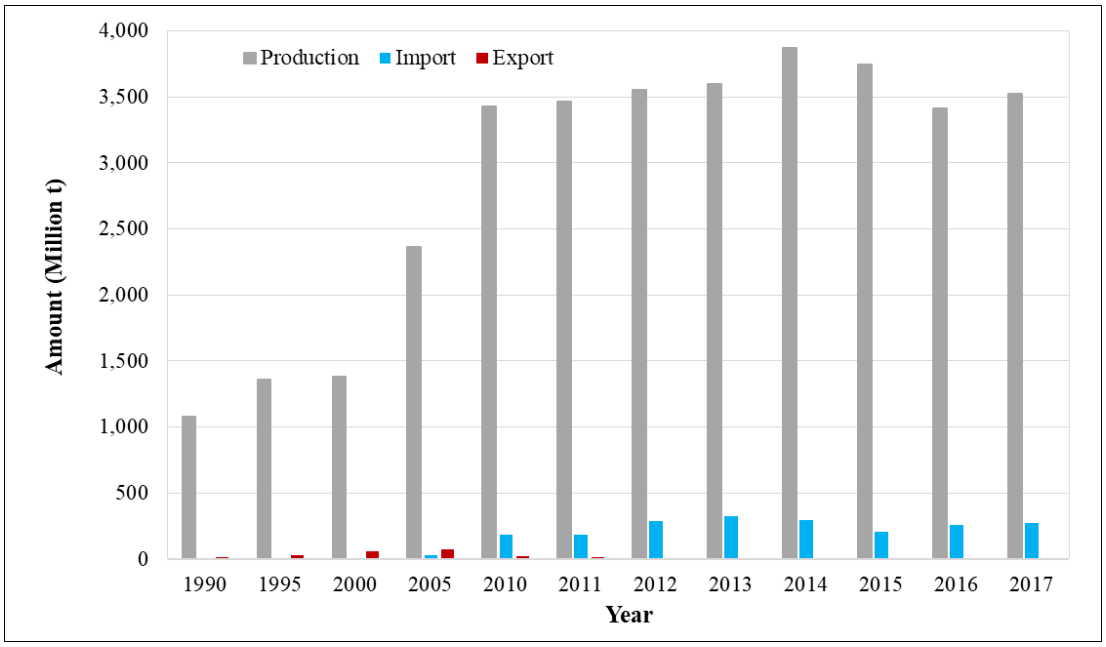

Figure 4: Production, import and export of coal of China (1990-2017).

It is obvious that coal consumption in China has been sustained mainly by domestic production. For a long time, imports of coal to China were relatively less than exports. China was a net coal exporter before 2005 and became a net coal importer from then on. Coal imports boomed at an unprecedented rate between 2005 and 2013. Accordingly, China imported more than 100 million tons of coal in 2009, then became the largest coal importer globally in 2011. Coal imports to China exceeded 200 million tons in 2012 and reached a high of 327 million tons in 2013, with a share of 6.8% of the domestic consumption. Imports reached 271 million tons in 2017, accounting for 7.1% of the same year's domestic consumption. In contrast with this fast import growth, coal exports have dropped substantially since 2005. The export

amount fell from a peak of 93.88 million tons to 45.43 million tons in 2008 and 7.51 million tons in 2013. Only 8.17 million tons of coal were exported in 2017, a 7% decrease from 2016 (CNCA, 2018). This implies that a very small portion of coal produced in China has been exported (stable at around 0.2% over years since 2012).

The structure of China's coal industry has also improved. All the key regions fulfilled their targets on coal consumption reduction between 2013 and 2017, due to regulations under the 'Air Pollution Prevention Action Plan' by the State Council. Coal production has a total of 250 million tons of overcapacity and this was phased out in 2017. The number of coal mines fell to less than 7,000 by the end of 2017. Among these, more than 1,200 were large ones with an annual production over 1.2 million tons and altogether, these mines contributed to more than 75% of the country's overall coal production. The number of coal mines with a production of less than 0.3 million tons per year fell to 3,200. Production at the four largest coal companies in China was 933 million tons in 2017, with a share of 26.5% of the country's total (CNCA, 2018).

3. Future coal consumption trends in China

Several studies analysed the pathways of China's CO_2 emissions up to the middle of this century in line with the country's current NDC target, the global 2℃ target or the 1.5℃ target. Future trends in coal consumption may be impacted by the corresponding changes in the energy mix under various scenarios according to these studies.

3.1 Coal consumption trends in a scenario consistent with the current NDC

Funded and coordinated by the Natural Resources Defense Council (NRDC), more than 20 influential organisations, including governmental think tanks, research institutes and industrial associations, jointly launched the 'China Coal Consumption Cap Plan and Policy Research Project' (hereinafter shortened as 'China Coal Cap Project') in October, 2013. The coal cap scenario set out by the China Coal Cap Project at the early stage is consistent with China's current NDC target, to peak the country's CO_2 emissions in around 2030. Specifically, Tian (2015) estimated the reduction potential of coal consumption by the cement, iron & steel, coke, building, electricity, coal chemical industries, as well as other sectors. The results are listed in Table 1. Under the reference scenario, overall coal consumption will increase until 2030 and peak at around 4.8 billion tons. This number will decrease slowly from then on but will still be over 4.2 billion tons in 2050. Through the implementation of capping coal countermeasures in major industries, coal consumption has the potential to be controlled at around 4.0 billion tons in 2020 and then fall quickly. This amount is predicted to be about 2.35 billion tons by 2050. Despite major differences among various industries, some measures to achieve this potential include the control of capacity scale, the optimisation of production structure, the improvement of technology level, and the development of fuel substitution at the sector level. In the short term, i.e., by 2020, there remains a certain level of reduction potential in all the major coal-consuming industries. The reduction potential of the power sector will become much more significant between 2030 and 2050, accounting for around a half of the total potential in coal reduction. This is mainly due to the retirement of old coal-fired power generation

units and the continuous advancement of power supply structure (Tian, 2015).

Another report by the China Coal Cap Project indicates that the share of installed capacity of coal-fired power generation will decrease from 70% in 2010 to 56% in 2020, 47% in 2030 and 33% in 2050 in the reference scenario. Under the coal cap scenario, this share will fall more quickly to 52% in 2020, 36% in 2030 and around 20% in 2050 (CCCP, 2015a).

Table 1: Coal consumption reduction potential by the industry (unit: 100 million tons)

Year	Reference scenario	Consumption reduction potential							Coal cap scenario
		Cement	Iron & steel	Coke	Building	Electricity	Coal chemical	Others	
2020	44.40	0.46	0.53	0.42	0.21	0.82	0.79	0.55	40.63
2030	48.18	0.41	0.76	0.59	0.60	5.64	1.58	1.64	36.97
2040	46.22	0.35	0.70	0.77	1.16	8.57	1.99	2.97	29.71
2050	42.58	0.25	0.33	0.77	1.92	9.68	2.27	3.89	23.47

Teng (2018) developed the 'PEAK-2030' and 'PEAK-2025' scenarios to show pathways in accordance with China's different mitigation ambitions. Under the 'PEAK-2030' scenario, CO_2 emissions will peak in 2030 at 10.3 Gt-CO_2, approximately 32.6% higher than the 2010 level. Thereafter, emissions will decrease considerably by 29.8% from the peak level to 7.3 Gt-CO_2 by mid-century. Accordingly, coal consumption will peak in around 2020 at about 3.03 billion tce (or 4.24 billion tons), and then decline by 12.0% to 2.66 billion tce (or 3.72 billion tons) in 2030 and by 45.4% to 1.65 billion tce (or 2.31 billion tons) in 2050. This transition pathway for coal consumption is consistent with the coal cap scenario in Tian (2015). The share of coal in primary energy consumption will decrease from 71.7% in 2010 to 46.8% in 2030 and 29.8% in 2050. The proportion of coal-fired power generation in overall electricity generation will decrease from 73.3% in the base year to 41.8% in 2030 and 15.0% in 2050. Conversely, the proportion of non-fossil electricity generation (including nuclear and renewables) will rise substantially from 22.0% in the base year of 2010 to nearly 80% by 2050.

3.2 Coal consumption trends in line with the global 2℃ target

Applying the Computable General Equilibrium Model (C-GEM), Zhang (2017) gives a transition pathway for low-carbon energy and economy in China by 2050. According to Zhang (2017), the achievement of the global 2℃ target is in line with the unconventional transition scenario of China's energy system, and requires China to peak its CO_2 emissions by 2020. Emissions are likely to fall by around 40% in 2050 from the 2015 levels. Total energy consumption will likely continue to increase to around 5.3 billion tce by 2030 and then decline to about 5.19 billion tce by 2050. However, the composition of energy consumption will be fundamentally changed. Accordingly, coal consumption will be stable at around 3.8 billion tons between 2015 and 2020, and then quickly decrease to 2.9 billion tons by 2030 and 1.8 billion tons by 2050.

The 'PEAK-2025' scenario in Teng (2018) is also consistent with the global 2℃ target, referring to early peaking of CO_2 emissions in 2025 at 10.2 Gt-CO_2. Emissions will then fall to 9.93 Gt-CO_2 in 2030,

nearly 0.4 Gt-CO_2 lower than the 'PEAK-2030' scenario, and 5.7 Gt-CO_2 in 2050, a reduction of around 44% from the peak level and 1.6 Gt-CO_2 lower than the 'PEAK-2030' scenario. Correspondingly, coal consumption will peak in 2020 at 2.98 billion tce (or 4.17 billion tons), and decline to 2.03 and 1.09 billion tce (or 2.84 and 1.53 billion tons) respectively in 2030 and 2050, approximately 135.2 and 563.6 million tce lower than the 'PEAK-2030' scenario. The proportion of coal consumption in total primary energy will be 46.3% in 2030 and 21.8% in 2050. The share of coal-fired power generation will decline to 41.3% in 2030 and 3.0% in 2050. The electricity from non-fossil energy will expand significantly to nearly 90% of total power generation by 2050 (Teng, 2018).

3.3 Coal consumption trends in line with the global 1.5℃ target

Assuming 230 Gt-CO_2 as China's total carbon budget and in order to be able to reach nearly zero emissions by 2050, CCCP (2018a) applied the Integrated Policy Assessment Model of China (IPAC) and analysed the emissions scenarios of China in line with the global 1.5℃ target. As the result, CO_2 emissions will peak between 2015 and 2020 and decline quickly from 2020 onwards. The energy structure of China needs to change fundamentally, and the share of renewables, nuclear, natural gas, coal and oil in the primary energy will be 35%, 33%, 14%, 14% and 5% respectively by 2050. Accordingly, coal consumption will decline significantly after 2020 and fall to 940 million tons by 2050.

Similarly, ERI (2015) is another study showing a scenario of deep de-carbonisation. Applying a power system optimisation model and assuming 2010 as the baseline year, the Energy Research Institute of the National Development and Reform Commission (ERI/NDRC) conducted the 'China 2050 High Renewable Energy Penetration Scenario and Roadmap Study', and depicted a pathway for China to gradually phase out fossil fuels, especially coal (ERI, 2015). The result indicates that China's end-use energy consumption in 2050 will be 3.2 billion tce under the scenario of high renewable energy penetration, of which, 900 million tce will be fossil energy. In terms of power supply, 91% of electricity will come from non-fossil energy and 86% will be from renewable energy. The primary energy supply will be 3.4 billion tce, of which, 62% will be from renewable energy. The replacement of coal-fired power plants by renewable power generation will push power coal to peak quickly at 1.45 billion tce in 2020 and then decline. Coal consumption in total will peak at 2.65 billion tce (or 3.71 billion tons) before 2020 and finally fall to 580 million tce (or 812 million tons) in 2050, accounting for 17% of overall use of primary energy. China committed to peak the country's CO_2 emissions by around 2030. The high renewable energy penetration scenario will drive emissions in China to peak earlier in 2025 at a lower value of 9.23 Gt-CO_2, and then decline constantly to 3 Gt-CO_2 by 2050, sharing 20% of the global total (ERI, 2015).

3.4 A summary of the forecasts on coal consumption in China

Based on the studies reviewed above, the forecasts for coal consumption in China under various scenarios are summarised in Figure 5. The analysis focusing on the scenarios consistent with the current NDC target achieved a similar result, predicting that coal consumption in China would exceed 4.0 billion tons by 2020, then gradually decrease to about 3.7 billion tons by 2030 and to 2.3 billion tons by 2050

(Tian, 2015; Teng, 2018). To be consistent with the global 2℃ target, China's coal consumption needs to fall quickly from the current level to around 2.9 billion tons by 2030, and continue to fall to a range of 1.5 to 1.8 billion tons by 2050 (Zhang, 2017; Teng, 2018). For the realisation of the global 1.5℃ target, coal consumption in China needs to keep decreasing to nearly 3.6 billion tons in 2020, then to around 2.5 billion tons by 2030 and fall below 1.0 billion tons by 2050 (CCCP, 2018a). This implies that China's coal-dominated energy mix has to change fundamentally under the scenarios in line with the Paris Agreement. By mid-century, coal consumption in China will decline to around 45% to 25% of the current level.

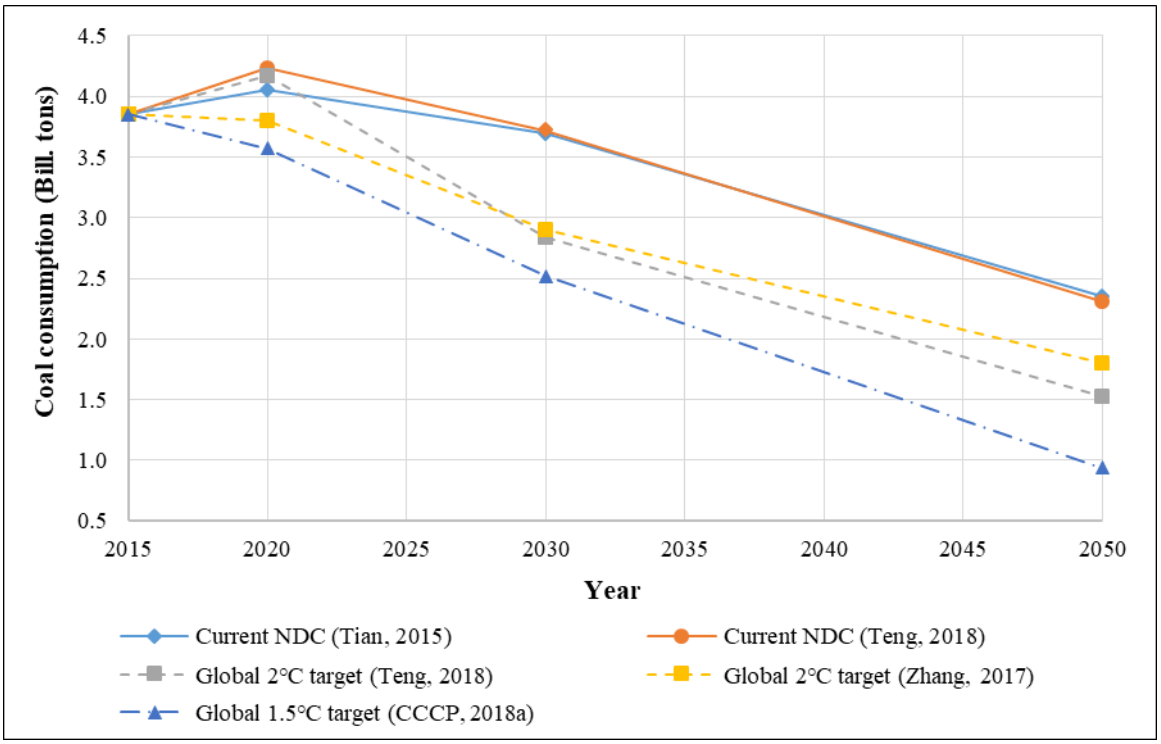

Figure 5: Forecasted coal consumption of China under various scenarios.

4. Changes and future trends in employment of the coal industry

4.1 Changes in employment of the coal industry

Using the data from China's statistical yearbook for various years, the employment in the coal mining and washing industry (referred as coal industry in this document) between 2000 and 2017 in China has been compiled and depicted in Figure 6. The results confirm that the average number of workers in China's coal industry was stable at just under 4.0 million before 2004. This amount quickly increased to over 5.0 million in 2008 and peaked at nearly 5.3 million in 2013. After that, employment in the coal industry quickly fell to less than 3.5 million in 2017. This level of employment is less than the number of jobs created by the renewable energy sector in China. As is well known, China remains the leader in renewable energy development worldwide. The country's total number of jobs in renewable energy was 4.1 million in 2018, accounting for 39% of the global total. Among these, 2.2 million jobs were for solar PV, 0.67 million were in the solar water heating industry, and wind employment accounted for an

estimated 0.51 million jobs (IRENA, 2019).

Overall, changes in employment in China's coal industry can be explained by variations in production amount and improved production efficiency largely attributed to coal mining mechanization and structural adjustment in the past. As shown in Figure 4, coal production in China more than doubled between 2000 and 2010, while the number of coal workers only increased by around one quarter over the same period. This was because labour productivity in the coal mining industry increased rapidly from 1993 to 2011. Since 2010, production amounts have been fairly stable at around 3.5 billion tons, with a subsequently slower growth rate in mining efficiency. The phase-out of excessive production capacity may go a long way to explain the sudden reduction in coal workers over recent years (CCPP, 2019). In spite of the large fluctuation in the number of workers in the coal industry, its share of total industrial employment indicates a continuously decreasing trend, from 7.18% in 2000 to 3.87% in 2017.

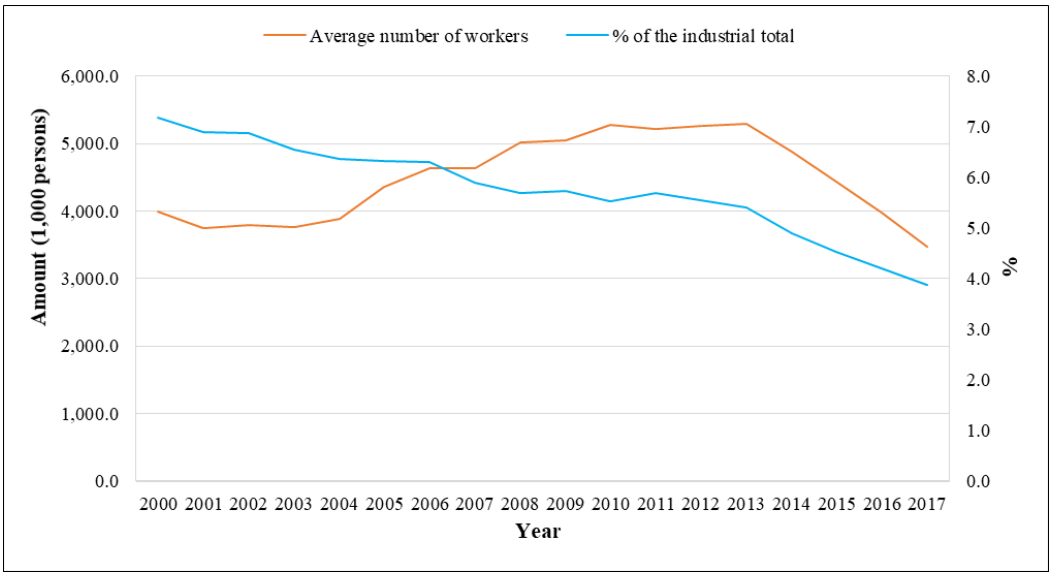

Figure 6: Average number of workers in coal industry and its share of industry (2000-2017)[2].

4.2 Structural adjustment of the coal industry as a main driver of employment changes

Efforts to carry out structural improvements to the coal industry in China are summarised as below.

The Chinese government implemented various measures to overcome the shortage of coal between 1978 and 1996. The implementation of a contract-responsibility system to encourage small local mines in 1985, and reforms on marketisation and acceptance of foreign investments from 1993 brought about not only a significant increase in coal production but also a massive number of mini coal mines (China Electric Power News, 2018). These mini mines suffered from problems surrounding production safety and environmental pollution. In 2005, the central government released the 'State Council Opinions on the Development of Coal Industry' and decided to deal with overcapacity problems under a principle to foster the large coal mining companies and the modernisation of production facilities. The mini mines

[2] Available at: http://www.stats.gov.cn/tjsj/ndsj. The statistics only covers coal mining and washing companies above the designated size (Main business income: ≥5 million Yuan by 2010 and ≥20 million Yuan since 2011).

were encouraged to consolidate with big companies or they would have to close if they could not meet the standards of safety production, environmental protection and resource utilisation efficiency (State Council, 2005). In 2007, the 'State Council Announcement on Comprehensive Action Plan on Energy Efficiency and Pollution Control' was released as the capacity phase-out policy for industries with high energy consumption, high pollution and intensive resource consumption, including the coal mining industry (State Council, 2007). However, no numerical target was put forward by the central government at that time. In 2010, the State Council decided to set mandatory targets for phasing out the overcapacity of 11 industries. Out of these, the coal industry was required to close 8,000 mines and phase out 200 million tons of overcapacity by the end of the same year to address two challenges. One was the pressure to achieve the target for energy efficiency in the 11th FYP period (2006-2010), and the other was economic recession due to the financial crisis in 2009 (State Council, 2010).

As listed in Table 2, China shut down a total of 16,716 small coal mines with a capacity of less than 300 thousand tons per year and eliminated 1.09 billion tons of overcapacity in coal production from 2006 to 2015. The targets for capping coal production by 2010 and 2015 were also achieved in comparison with the actual production amount as shown in Figure 4. According to the '13th Five-Year Plan for Coal Industry Development', 3,700 small mines with a total of 800 million tons of capacity will be further phased out by 2020. Assuming the 2020 targets are achieved, the number of mines will decrease from 80,000 at the maximum in 1980s to 6,000 by 2020. In reality, the number of mines sharply decreased to around 5,800 by the end of 2018. As the result, the average production capacity per mine increased about sixtyfold from 1988 to 2018, or changed from 15.2 thousand tons to over 900 thousand tons within 30 years (CNCA, 2019).

Table 2: The achievements of coal mine closure and overcapacity phase-out (2006-2020)

Period	The 11th FYP period (2006-2010)	The 12th FYP period (2011-2015)	The 13th FYP period (2016-2020)
Capacity phased out (100 million tons)	5.4	5.5	8 [1]
No. of closed mines	9,616	7,100	3,700 [1]
Target of production volume (100 million tons)	34.3 (2010)	37.5 (2015)	39 (2020)
Note: [1]: The number is the target for 2020. Sources: NDRC and NEA (2012); NDRC and NEA (2016b)			

The capacity reduction plan of main coal production provinces (with annual production over 100 million tons) in the 13th FYP period (2016-2020) and the targets for 2016 and 2017 is further listed in Table 3. The overall target during the 13th FYP period is expected to be fulfilled in 2018 ahead of the planned schedule since about 440 million tons of capacity were withdrawn in 2016 and 2017. The removal of excessive production capacity has greatly improved the demand-supply relationship of coal market and the business operation of coal industry in China. Accordingly, coal prices increased dramatically in the second half of 2016. The overall profit of the whole sector was only 44.1 billion Yuan in 2015, while this amount increased to 109.1 and 295.9 billion Yuan in 2016 and 2017, respectively (CCCP, 2018b).

Table 3: Capacity reduction plan of main coal production provinces in the 13th FYP

Province	No. of mines in 2015	Approved annual production (Mill. tons)	Target in the 13th FYP		Plan of 2016		Plan of 2017	
			No. of mines to close	Withdrawn capacity (Mill. tons)	No. of mines to close	Withdrawn capacity (Mill. tons)	No. of mines to close	Withdrawn capacity (Mill. tons)
Hebei	198	124	123	51.03	56	14.58		7.42
Shanxi	541[1]; 537[2]	880[1]; 580[2]		>100	25	23.25	18	17.40
Inner Mongolia	588	1,151	65	69.55	10	3.3		1.2
Anhui	58	157		31.83	9	9.09		7.05
Shandong	143[1]; 8[2]	180	114	64.6	58	16.25	14	4.82
Henan	470	210	256	62.54	89	22.15		20
Guizhou	1,260	314	510	>70	147	23.68	120	15
Yunnan	788	138	139	>70	121	18.65		1.54
Shaanxi	183[3]	292[3]		47.06	42	18.24		
Ningxia	98	138	17	11.19	8	1.07		

Note: [1]: Amount in operation; [2]: Amount in construction; [3]: Not include the companies owned by the central government.

4.3 Prediction of the future employment in the coal industry in China

Employment in the coal industry is determined by various factors, such as overall coal production, coal mining technology level and the scale of coal mines and companies. Out of these, improvements in mining efficiency has a major influence on employment. The average number of workers required to produce 10,000 tons of coal halved from 29 in 2000 to 14 in 2012 (CCCP, 2015b). Using the amount of coal consumption estimated by Tian (2015) as listed in Table 1, CCCP (2015b) predicted the future employment scale of the coal industry in China. The results can be seen in Table 4.

Table 4: Employment of coal mining industry in various scenarios (unit: 10,000 persons)

Technology	Coal consumption	Year					
		2012	2015	2020	2030	2040	2050
Base technology scenario	Base scenario	518	477	418	351	261	186
	Coal cap scenario	518	463	383	269	168	102
	Direct employment impact	0	-14	-35	-82	-93	-84
Optimized technology scenario	Base scenario	518	433	324	272	202	160
	Coal cap scenario	518	420	296	208	130	88
	Direct employment impact	0	-13	-28	-64	-72	-72

Note: Base scenario of technology: Mining efficiency improved by 5% annually. Optimized technology scenario: Production efficiency improved by: 8% by 2020; 5% during 2020-2040; 3% during 2040-2050.

It is indicated that Chin's coal industry faces a big challenge due to a shrinking employment rate. Overall employment in this industry is likely to fall to less than 1.0 million by 2050 under the coal cap and optimised technology scenario. This may be largely attributed to improvements in technology and mining efficiency. Coal cap scenarios would promote technology improvement of coal companies and structural change of the whole industry, and expand this effect further. More specifically for the optimised

technology scenario, coal cap policies would have a direct impact on employment in the coal mining sector. Under the coal cap scenario with the consumption amount listed in Table 1, employment would be reduced by about 0.72 million jobs by 2050 in comparison with the base scenario. A natural reduction in employment due to improvement in technology would be much larger, falling from 5.18 million in 2012 to 1.6 million by 2050. This implies that coal cap countermeasures accelerate this process and would reduce the total employment in the coal industry by an additional 20% (CCCP, 2015b).

On the other hand, coal cap policies speed up the development of alternative energy and energy services. This will be able to create more green jobs to cover the employment loss from the coal industry and the large coal-consuming sector, i.e., coal-fired power plants. The development of new energy and the related technology has high demand for labour. According to ERI (2015), high penetration of renewable energy would create a total of 12 million jobs in renewable-related industry by 2050. Out of these, employment for solar power generation and heat utilization and the manufacturing of solar PV equipment would account for the largest share and would create up to 4.8 million jobs. Wind power related industry would create 3.8 million jobs. The diffusion of renewable energy requires support from new industries like electronics, research & development, and thus promote the movement of the working population from conventional sectors to advanced industry (ERI, 2015).

However, newly created employment opportunities are not necessarily suitable for low-end workers from the coal industry (CCCP, 2015b). Generally, the average education level of employees in coal companies is low. As of the end of 2010, there were about 5 million employees in China's coal industry. Among them, 889,000 employees had a college-level education or above, accounting for 16.87% of the total. This share was 16% lower than that of the energy industry in the same year. Most workers in coal mines are off-farm workers and are particularly vulnerable to the consequences of coal industry transition (Teng, 2018).

5. Challenges, policies and good practices for China's coal industry transition

5.1 Difficulties for the transition of coal industry in China

Due to the low concentration degree of China's coal industry over a long period, it is difficult to truly form an effective driver for the reduction of excessive and backward coal production capacity. There is still a big gap between the capacity phased out and the required scale. At present, there are still many small coal mines in China with an annual production capacity below 300 thousand tons. They often lack safe production conditions, and are inconsistent with coal industry policies.

There exist various difficulties for the phase out of excessive production capacity of coal industry in China. Firstly, the areas where coal mines are located have a limited ability to absorb surplus labours due to the unitary industrial structure. Workers from coal mines that have closed in the past few years have largely been resettled within the coal companies, but further resettlement internally by the companies themselves has become more and more difficult. Secondly, it has not been possible to appropriately process the asset loss of many coal mines that have been shut down . Most of the debts

incurred by coal mines have been unified loans of the group companies. It is therefore difficult to separate and dispose of the debts held by closed coal mines. Thirdly, there are many stakeholders related to jointly-owned coal mines, and it is difficult to close mines such as these (CNCA, 2018). From a short-term prospect, the overall production capacity of the coal industry is too large, and it is still a very arduous task to phase out excessive capacity. Along with the production of raw coal that is to be gradually concentrated into those regions with rich resource endowment and competitiveness, coal supply has been changing geographically. This poses new challenges to the transportation network and capacity (CNCA, 2018).

Difficulties have also emerged in the business operations of some coal companies. The asset-liability ratio of coal companies above the designated size was 67.8% in 2017. High corporate debt makes it more difficult to obtain new financing. Due to the large volume of debts, it is basically impossible to improve the profitability of some coal companies. More than 20% (20.6%) of coal companies experienced a financial deficit in 2017. In addition, the technological upgrading of coal mines requires a large number of capable workers. However, there has been a serious outflow of quality human resources from coal companies in recent years. As a result, the original workforce in the coal industry is rapidly ageing, and it is difficult to recruit new qualified workers (CNCA, 2018).

Social equity poses another challenge for coal industry transition in China. Coal-rich regions that have based their revenue system on coal resources will face job losses in the coal industry and will need to tackle the related social and economic problems. Therefore, coal transition needs to be complemented with other policies, i.e., countermeasures to facilitate the reemployment of mine workers, and financial transfer to assist in the transition of coal related industry and regions (Teng, 2018).

5.2 Policy measures for coal industry transition in China

Referring to the format in previous literature (i.e., Green, 2018; Spencer et al., 2018), policy measures adopted in China for coal industry transition in recent years are summarised in Table 5.

According to the authors' interviews with related experts in China, around 1.3 million coal workers are estimated to be affected during the 13th FYP period due to the elimination of overcapacity in this industry. Various efforts have been made mainly for the settlement of the affected coal workers. The central government prepared a total of 100 billion Yuan as a special subsidy fund for the elimination of overcapacity of coal and iron & steel industries by 2020 (The Economic Daily, 2016~~8~~). This fund may go to state-owned companies directly, and to non-state-owned companies via the provincial governments. The fund should be firstly used for the settlement of unemployed workers, including benefits for early retirement of employees with certain conditions, economic compensation for laid-off workers, reimbursement of historical arrears like wages, social insurance and so on. In 2016, 41.8 billion Yuan have been spent on 700 thousand workers (People's Daily, 2017). The subsidies eventually paid to coal companies are expected to reach 77.2 billion Yuan (CCTD, 2016).

In addition, special allowances are provided from the 'Unemployment Insurance Fund' for companies

with unemployed workers due to the removal of overcapacity until 2020. The subsidy rate is 50% of the total amount of insurance paid in the previous year by the company and its employees, and it is used as compensation to retirees, and for training expenses (MOHRSS, 2014).

Table 5: A summary of policy measures for coal industry transition in China

Policy target	**Policy measures**			
	Backward-looking		Forward-looking	
	Compensation	Exemption	Structural adjustment aid	Holistic adaptive support
Coal workers	● Early retirement benefits for employees with certain conditions ● Pay economic compensation, and pay off wages and social insurance for the laid off workers	None	● Various forms of subsidized training for the reemployment ● Build human resources matchmaking platform and provide professional services	● Preferential loan, tax, subsidy and rewards to encourage the innovation and new business creation by the affected workers
Coal mining companies	● Financial subsidy to the central enterprise groups for the elimination of overcapacity of coal industry ● Special allowance for companies with the unemployed due to the removal of overcapacity	None	● Encourage coal companies to develop new businesses for industrial structure adjustment and the relocation of diverted employees	
Communities/ Regions	● Financial subsidy for the elimination of overcapacity of coal industry via provincial government	None	None	● Largely develop the tertiary industries like tourism and ecological agriculture in coal production areas

5.3 Good practices for the transition of coal industry in China

Similar to the total employment in the coal industry all over the country, employment in the main coal production provinces reveal a gradually growing and then declining trend. Employment in some provinces, such as Shanxi, Shaanxi, Hebei, Inner Mongolia, Guizhou and Yunnan, peaked in 2013. In some other provinces like Shandong, Henan and Anhui, employment peaked in 2012. Employment in Heilongjiang reached its maximum in 2011. This implies that the transition of the coal industry is already happening but that there are geographical differences due to the specific characteristics of various regions (CCCP, 2018b). In more detail, employment in the coal industry in 2015 was reduced by 110.5 thousand in Heilongjiang compared to peak levels. The provinces of Henan and Shandong followed a similar trend with a reduction of 96 thousand. There were reduction of 91.6, 76.1 and 35.1 thousand in Anhui, Shanxi and Inner Mongolia respectively.

During the removal of excessive production capacity in the coal industry, clear plans and countermeasures were implemented for the resettlement of employment in some provinces according to local conditions. One good example of this was in Shanxi province, which decided to suspend the approval of coal-related projects after 2016, and introduced a production system of 276 working days per year. Shanxi provincial government issued the 'Implementation Proposals for the Structural Reform of Coal Supply in Shanxi' in April, 2016, and planned to eliminate more than 100 million tons of coal production capacity by 2020 as well as capping the total production per year at 1.0 billion tons. Together with the other seven related departments, the Human Resources and Social Security Bureau of Shanxi province issued the 'Implementation Proposals for the Employment Resettlement during the Removal of Excessive Capacity of Coal and Iron & Steel Industry'.

In 2016, Shanxi released a total of 1,213 million Yuan of award funding to support the phase-out of overcapacity in the coal and iron & steel industries. An additional 365 million Yuan was spent to subsidise reemployment using the special provincial fund for employment and the unemployment insurance fund. From those coal companies whose overcapacity had been removed, 17,914 workers could be diverted and settled in 2016. As listed below, various resettlement measures were proposed and practiced by addressing the core responsibility of coal companies and the support function of government (CCCP, 2018b).

- To ensure reemployment as much as possible within coal companies. According to each employee's personal characteristics and their willingness to work, various methods were adopted for resettlement. As a result, only 1,489 coal workers had their contracts terminated voluntarily in 2016, which was a mere 7.11% share of the total for resettlement in the same year. Most of the employees were transferred to other work without being laid off, allaying any fears of social instability.
- To establish human resource companies to assist in the reemployment of coal workers. As an example, Shanxi Coking Coal Group invested 20 million Yuan and set up a human resource company to provide professional services supporting the reemployment of coal workers.
- To promote the transition and upgrading of coal companies through technology innovation. The establishment of various innovation centers was encouraged. Accordingly, the idle assets of coal companies were able to be revitalised via market-oriented mechanisms and capital operations to create more new jobs to divert employment from the coal industry.
- To improve the reemployment capability of coal workers themselves by the arrangement of professional training.
- At the regional level, to develop new industry for restructuring the local economy and the transfer of employment.

6. Conclusions and suggestions

The key to the phase-out of excessive coal production capacity is to establish a comprehensive

mechanism to remove backward capacity with the fewest economic and social consequences. Complementary policy package should be implemented given that coal workers generally have low education levels and limited reemployment options.

- Similar to the recommendation in CCCP (2018b), for the provinces and cities with a local economy relying on coal resources, a more systematic transition and upgrading plan should be established to restructure the local industry. Through the revitalisation of coal-related industries, the employment loss from coal mines could be recouped by the newly-created jobs. By nurturing new and alternative industries, coal workers who lost their jobs due to the depletion of coal resources and the closure of backward production capacity, may be reemployed in new and appropriate positions.
- As for financial countermeasures, the central government should provide a strategic fund or budget transfer to assist the local government during this transition process (Teng, 2018). Local governments should implement active financial policy to invest in public projects, thereby increasing employment opportunities. The employment capability of small and medium businesses should be enhanced, i.e., by cutting their tax burdens.
- Appropriate social security systems must be established and enhanced for the reemployment of affected people and prevent them from falling into poverty, for a just transition. In regions where employment by the coal industry has been seriously reduced, social security should focus on medical care, pensions, unemployment insurance to ensure a minimum living level for the laid-off workers (CCCP, 2018b).
- Preferential measures should be provided to support coal workers to become self-employed, especially those laid-off ones. Economic incentives include small guaranteed interest loans; tax exemptions; subsidies for venue rental, social insurance and first time entrepreneurship; and, even rewards for reemployment.
- There should be more opportunities for the work force to carry out learning and training to ensure job stability. Human resources and the social security department have an important role to play in enhancing the skill reserve and quality of workers to encourage the local economy to operate in a healthy way (CCCP, 2018b).

Acknowledgements

This study was funded by the strategic research fund (SRF) of IGES in fiscal year 2018. Dr. Mark Elder and Dr. Yuji Mizuno at IGES provided insightful comments on the draft paper at the early stage. Proofreading of the manuscript was carried out by Ms. Emma Fushimi at IGES. The authors wish to express great thanks to all of them.

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Institute for Global Environmental Strategies（IGES）
Climate and Energy Area

2108-11 Kamiyamaguchi, Hayama, Kanagawa, 240-0115, Japan

Tel：046-855-3700 (Representative), 046-855-3810 (Lead author)

Fax：046-855-3809

E-mail: ce-info@iges.or.jp

URL: www.iges.or.jp