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China and Coal:

An Imminent Break-Up?

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INTRODUCTION

Home to one sixth of world population; 1.3 billion people, (Exxon Mobil - China Edition, 2015), China is also the number one energy consumer on the planet since 2010. And what's more, the country provides electricity to its inhabitants with its most abundant and primary fossil fuel resource; coal. Besides being the most inexpensive source of energy so far and being generously available underneath the Chinese soil, coal is also known to be the most pollutant fossil fuel on the planet, and is assumed to induce 44% of worldwide energy-related CO2 emissions, (Nijhuis, 2014). In such context, China has announced in 2014 that it would enter into a joint landmark climate agreement with the US in order to fight global warming, by substantially reducing its CO2 emissions by 2030. Indeed, with its feet deeply rooted to the problem, 'the world's largest emitter of greenhouse gases' from this past decade, (Biello, 2010) has nonetheless set an ambitious goal by 2030: to peak its CO2 emissions and increase its non-fossil share in primary energy consumption by 20%, (US-China Joint Announcement on Climate Change, 2014). To achieve such prospect, the Chinese government would have to successfully perform a major shift in its economic structure. Such fundamental changes would send shock waves not only to the Chinese coal market but also globally. Therefore, this paper seeks to assess the outlook of coal in China in the near- and long-term future, and more narrowly, address the key aspects that surround such an important transition from coal to a greener energy-mix. Through a comprehensive literature review, our goal is to provide a full scope of the main issue at stake: Does China's newly adopted attitude towards coal imply an imminent break-up?

Firstly, we will briefly introduce the coal industry and give an overview of the key trade flows, followed by a short S&D analysis of the global coal market. In addition, given China's prominent role in tomorrow's coal outlook, we will take an in-depth look at its current market conditions. Secondly, we will evaluate to what degree China is reliant on coal not only in terms of its energy mix but as well of its GDP growth. Thirdly, we will examine what are the key drivers that have triggered China to change its attitude towards coal, with a main focus on environmental issues. Then, we will summarily review China's toolbox to reach its target: recent announcements, new policies and reforms to take place. Finally, we will examine the different solutions that China is considering in order to phase out of thermal coal-generated energy, making parallel comparisons with key countries, such as the US, Germany and France, who are pioneers in those alternative solutions.

Throughout our paper, we have focused our work primarily on thermal and steam coal, with a moderate attention to metallurgical coal. Furthermore, the scope of our analysis will principally be limited to Asia Pacific, which is at the heart of the thermal coal market.

I. COAL INDUSTRY OVERVIEW

Major Trade Flows

About 57% of the world's proved coal reserves are shared between 3 countries; USA, Russia and China respectively, (Mining Technology, 2013). Although a country's production capacity is usually highly dependent on its domestic resources, China is the exception to the rule. Indeed, despite only having 12.8% of the world's proved coal reserves, (BP, 2014), it is the number one producer with 48,1% of global coal mined in 2013, (BP, 2015), therefore outpacing the US, which holds twice the amount of China's reserves, or 26.6%, (BP, 2014). However, it is said that at this current pace of production, China's coal reserves would be just enough to satisfy 34 years of domestic consumption, (OIES, 2014).

Global coal consumption has grown strongly in Asia over the past decade, more than any other source of energy, driven mainly by China's economic surge and heavy industrialization and hence, growing needs for power and steel production. Indeed, with 70-80% of its country powered by coal, China consumed about 49.6% of global coal in 2013, (BP, 2015), which is as much coal as the ROW combined, making it thus the world's biggest consumer.

Most of today's seaborne trades are concentrated in the Asia Pacific region, where over half of thermal coal demand is located, with top buyers such as China and India. Last year, both countries accounted for 53.3% of global imports, with a lead of 27.4% from China, (Wood Mackenzie A, 2015), making it the world's first importer. Quite interestingly, while the US and Russia export most of their domestic production, China is the only one to be a net importer. 'As the world's largest coal producer, China has become the 'swing buyer' of the coal market, buying when international prices are lower than domestic steam coal prices and largely relying on domestic coal when imports are unattractive', (OIES, 2014), which is key evidence of the nation's deep ties to coal and hence, its well-deserved 'King Coal' nickname.

Since coal is a heavy commodity to export, producers usually sell their output to neighboring countries in order to limit freight costs. Therefore, nearly 70% of major seaborne exports are covered by Indonesia (45.5% in 2014) and Australia (24.4% in 2014), (Wood Mackenzie A, 2015), with respectively one third and one quarter of their exports that are assigned to China, (Woodmac H, 2014).

Given its triple role as the main producer, consumer and net importer, China is undeniably the most dominant player in today's coal industry, having a lead on both global demand and supply. In that sense, a future China without coal would be difficult for producers reliant on the country's demand, and such scenario would therefore deeply affect the coal industry.

Today's Global Depressed Market

Globally, today's outlook is merely a continuation of yesterday's depressed market: chronic oversupply, weaker demand and subsequent price fall. Indeed, further to the US Shale Gas Revolution, which led the country to dump its oversupply on the market, a slowdown in Southeast Asia power demand growth has significantly weakened thermal coal demand, with net fallbacks from key consumers, such as China (-3.5% according to NEA data) and India, (Myllyvirta A, 2015). As a result, the increased oversupply has only further pushed down international prices. As seen in Figure 1, all three FOB indexes at 6'000 kcal coal for Newcastle, Indonesia and Qinhuangdao, -which are the main benchmarks in the seaborne region, have been in free fall since 2011. 'Benchmark thermal coal prices in the seaborne market are trading below the marginal cost of supply for many producers' according to Wood MacKenzie analysts, and thus won't fall significantly lower in 2015, (Woodmac C, 2015). However, with a weak demand and a chronic oversupply, no meaningful price recovery is expected in the short-term either.

Figure 1: FOB Prices at 6,000 kcal/kg (World Bank, McCloskey, 2014)

On top of that, devalued exporting currencies have also depressed coal prices, (IEEFA, 2015), undermining thermal margins of top suppliers like Australia, Indonesia or South Africa, while subsequently benefitting top importing countries with production in USD, such as China. Nonetheless, the Russian rubble's steep downfall (-70%) has enabled the country to increase its exports to the Pacific by about 8 million tonnes, (Macdonald-Smith, 2015), achieving market shares from top seaborne suppliers Indonesia and Australia. This achievement highlights Russia's potential to become a key exporter, especially given its proximity to northern Asia. 'Exporter currency declines will significantly lower the global seaborne cost curve, lowering the likely equilibrium pricing outcome materially in 2015', (IEEFA, 2015). Such depressed market conditions have inevitably devalued the rating of coal companies, notably in China, which marks a major turning point for 'King Coal', (IHS Energy B, 2015).

Market Conditions in China

In 2014, Chinese demand dropped 2.9%, its first decline since 1988, (OIES, 2014). For the first time in 14 years, coal consumption and production also fell in 2015, (PUKO and YAP, 2015). This slowdown in demand growth reflects the end of the country's rapid industrialization, trade growth and urbanization, as the economy matures. In 2014, the country's industrial growth dropped 5.6% in March, 6.4% for Q1, which marks the lowest quarterly figure since Jan-Mar 2009, (IHS Energy B, 2015). Today, its economy should continue to grow –however, at a slower pace and driven by a greater share of the service sector and less by the heavy industry and manufacturing. In fact, President Xi considers it today as 'the 'new normal' for the Chinese economy, which he characterized as a moderation from ‘super-fast’ to ‘relatively-fast’ growth’, (UK Trade & Investment, 2014).

Such drop in demand growth only further aggravated domestic overcapacity in China, which triggered the government to restrict domestic coal outputs. Consequently, in 2014, ‘more than half of China’s coal production was operating with negative cash margins’, (Woodmac H, 2014). Its biggest coal-mining group, Shenhua Energy Group, lowered its output by 10%, or 50 Mt less than its initial 2014 target, (OIES, 2014), cutting down its imports by 100%, and its sales down 32.1%, (Intel et al., 2015). Although 2015 marks the second year of government-imposed output cuts for China, which has already resulted in an overall decline of 2.5% in 2014, (IHS Energy B, 2015), it still isn’t enough to offset weaker demand and hence oversupply is still high. In fact, IHS Energy thinks ‘the massive increase in stocks at the mines, ports, and power stations will take at least a year to clear, even if government policy to reduce output from smaller mines is successful’, (IHS Energy C, 2015). Furthermore, IHS Energy believes absorbing this overcapacity could be done in the short-term, but would require strict discipline among producers, which is not guaranteed.

While these regulated outputs may have led to a short-term uplift in domestic prices, they have also contributed to a further slide in seaborne prices. And as a result of the stagnating low demand and oversupply, weak prices are expected to continue domestically and globally. ‘Fierce competition has developed between foreign and domestic suppliers, leading to a downward spiral of coal prices’, (UK Trade & Investment, 2014). At Qinhuangdao, China's biggest port, domestic prices fell 20% yoy last April, (IHS Energy C, 2015). Immediately, the government requested major coal groups in April 2015 to stop all price cuts, effectively setting a floor for thermal prices, (IHS Energy B, 2015). As a result, like the rest of the world, China’s outlook for thermal coal prices is not too promising in the short-term, with no meaningful price recovery expected either, at least not until the oversupply is absorbed or until a significant restocking demand is in sight.

II. CHINA AND COAL: AN INTRICATE RELATIONSHIP

The Importance of China to Coal and Vice Versa

China has many energy intensive industries that drove the country to become in 2007 the world’s largest energy producer; in 2010 the world’s largest energy consumer; and in 2011 the world’s largest power generator, (Eia.gov, 2014). China produces nearly 48% of global coal output, accounts for 69% of the ‘increase in global coal production over the past 10 years’, and for 50% of worldwide annual coal consumption as we seen, (Eia.gov, 2014). Additionally, its coal consumption nearly tripled during the past 10 years, leading the coal market expansion for the past decade. Coal supremacy in China is contextual: it accounts for 94% of China’s proven fossil fuel reserves. Subsequently, over the past 14 years Beijing has invested ‘US$511 billion in the mining, beneficiation, production and supply chain of coal', (Kehui, 2014). This equals to 20% of the total investment in China's energy sector. Beijing saw in these heavy investments the opportunity to back the country's annual energy consumption growth of 8.6% along with its economic growth thanks to a domestic and cheap coal. Hence, China is essential to the coal market, while in the meantime coal is critical for the country's economic growth. Indeed, China's primary energy mix is heavily tilted toward coal: '70% of its total energy consumption'; which is 'considerably higher than 30% globally', (Qili, 2013). The power generation sector accounts for 56% of China's total coal consumption. This contrasts with 80-90% for the OECD countries; the main difference being that coal consumption in China is not only driven by its power sector but also by its heavy industry sector, accounting for 28% (OIES, 2014). Its power sector is driven by a strong electricity demand that three folded since 2000 'from 1'350TWh to 5'330TWh in 2013', (OIES, 2014). China's electricity demand is strongly correlated with the country's industrial demand as 70% of all electricity produced goes to satisfy the industry sector, four times more than in the US (OIES, 2014). In other words, 80% of China's coal consumption goes to its industrial sector either as raw coal or electricity, (OIES, 2014).

Coal and GDP: A Love-Hate Relationship

To further study the relationship between China's economy and its coal industry we analyzed historical data from the National Bureau of Statistics of China and from BP data bank to build below figure 2. The trends between China's economic growth, coal production growth and coal consumption growth suggests a positive correlation. Subsequently, China's 'economic growth could not have occurred without sufficient coal supplies'. Equally, economic growth boosted by cheap source of power has 'promoted the overall growth and development of China's coal industry'. Indeed, China's GDP growth appears to be correlated to coal production and consumption growths with an average correlation of +0.54 and +0.55, respectively from 1985 to 2014. This background has thus 'led to a unique, complementary interdependence between China's coal industry and its economy', (Heping, Hong and Gang, 2014).

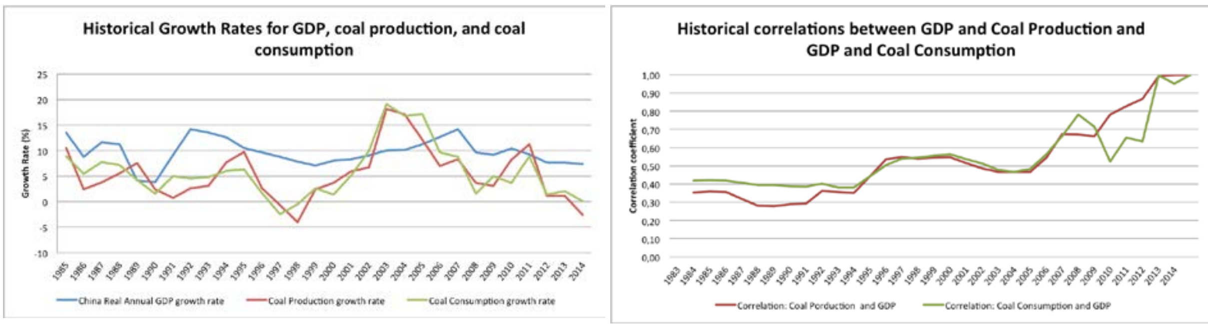

Figure 2: Source: NBSC, BP, 2014

Further than just the positive correlation between China's GDP growth and coal production and consumption growth, some researchers argue that economic growth is indivisible from an increase in coal consumption and CO2 emissions. The links between GDP growth and energy consumption in China were studied by Han, Fan and Wei (2004), Wolde-Rufael (2004), and Zhao et al. (2008). All studies ‘concluded that both variables produced feedback causality’ as the ‘growth of GDP is a forceful driver in increased energy consumption’, (Chang, 2010). Shiu et Lam (2004) and Yuan et al. (2007)’s studies concluded that China manifests unidirectional Granger causality, running from electricity consumption to real GDP. Then, Xiangzhao and Ji (2008), and Zhang and Cheng (2009) concluded that GDP growth is indivisible from increases in both energy consumption and CO2 emissions. Finally, Chang (2010), using a multivariate co-integration Granger causality tests, concluded that the pursuit of economic growth inevitably increases energy consumption and CO2 emissions in China. Li, R. and Leung, G. (2012) investigated the nexus between coal consumption and China’s GDP growth using a panel co-integration and error-correction modeling framework. Their findings showed that the variables are co-integrated, with causality tests indicating bidirectional causality between GDP and coal consumption. Bloch, H., Rafiq, S. and Salim, R. (2012)’s work showed that there is a unidirectional causality running from coal consumption to GDP growth in both the short and long run, under the supply-side analysis. They also proved a ‘unidirectional causality running from income to coal consumption in the short and long run under the demand-side analysis’ for China, (Bloch, Rafiq and Salim, 2012). Govindaraju and Tang (2013), using newly-developed co-integration analysis for an extended time period, successfully proved that ‘bi-directional causality, in the short and long run, is detected between economic growth and coal consumption (…) in China’, clearly establishing a positive link between coal consumption and Chinese economic expansion as shown in below Figure 3. Finally, Bloch, H., Rafiq, S. and Salim, R. (2014) showed that for ‘both the supply-side and demand-side equations, there is long-run bi-directional causality between GDP and coal’, and ‘a 1% increase in output leads to a 0.819% increase in coal consumption’, (Bloch, Rafiq and Salim, 2014). Consequently, the causality between CO2 emissions, coal consumption, and economic growth in China leads to conclude that GDP growth induces a higher level of coal consumption. Therefore, although reducing coal consumption ‘seems to be a viable option in reducing CO2 emissions, its impact on economic development can be negative’, (Chandran Govindaraju and Tang, 2013).

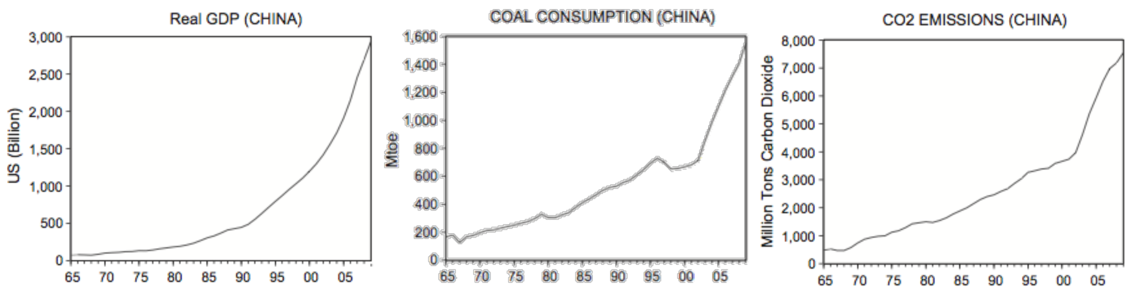

Figure 3: China's Real GDP, Coal Consumption, CO2 Emissions (Chandran Govindaraju and Tang, 2013)

A Critical Decoupling

Regardless of historical interdependence of coal consumption and GDP growth in China, different recently conducted studies pinpointed at an imminent decoupling. Heping, Hang and Gang built an index called the GDP-coal dependence index based on four different indicators. *GDP coal intensity index* (1) 'reflects the level of dependence of the national economic growth on coal'. From 2000 to 2012, the study demonstrated that 'China's overall coal consumption per RMB 10,000 GDP has generally declined' as the Chinese government implemented 'energy consumption restrictions with quantitative quotas for energy conservation', (Heping, Hong and Gang, 2014). *GDP coal-elasticity coefficient* (2) 'reflects the sensitivity of the GDP to coal production and consumption'. From 2000 to 2012, for every 1% GDP increase, coal production increased by 0.79% and coal consumption by 0.80%. In 2011 it declined to 0.48 and 0.14, reflecting the decrease in GDP coal dependency, (Heping, Hong and Gang, 2014). *Coal's contribution to energy consumption* (3) is defined as the 'ratio of annual increase in coal consumption to the increase in total energy consumption', (Heping, Hong and Gang, 2014). Averaging 66% from 2000 to 2012, it dropped down to 21% in 2012, translating a diminution of coal's share in the energy mix. Finally, the *coal-related industries contribution to GDP* (4) shows that from 2005 to 2010, it averaged 18%, and suddenly diminished from 22.2% in 2011 to 13.2% in 2012, indicating a slowdown of the contribution, (Heping, Hong and Gang, 2014). Based on those four indices, Heping, B., Hong, L. and Gang, W. (2014) built the GDP-coal dependence index, as seen in below Figure 4. This index, after displaying a consistently increasing momentum of the interdependency until 2011, has dropped by more than a half in 2012, pinpointing an upcoming decoupling.

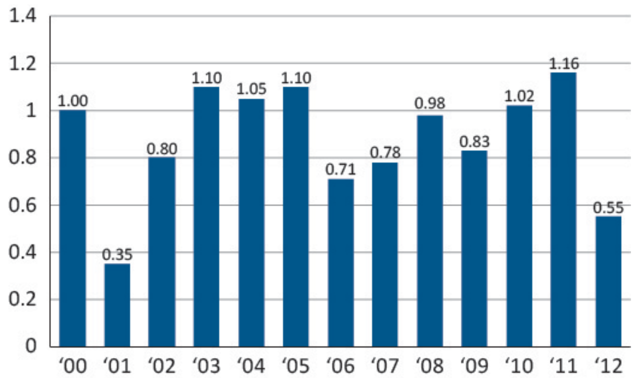

Figure 4: China's GDP Coal Dependence (Heping, 2014)

In addition, Platts confirmed that the 'old nexus between China's GDP growth, power and coal demand' undeniably began to break in 2012. The decoupling further accentuated in 2014 as China's coal demand was -1.2% during the first three quarters of 2014 and domestic coal consumption 'declined by 2.1%' over 2014 against 2013, with further decreases expected in 2015', (OIES, 2014 and Platts, 2015). Additionally, 'China's GDP grew by 7.4% in 2014 compared to

7.7% in 2013', while power demand growth fell by almost half, and coal demand barely grew' clearly highlighting the interdependency disruption (Woodmac G, 2015). This unprecedented decoupling 'comes amid broader commitments to reduce CO2 emissions per unit of GDP by 40-45% between 2005 and 2020 and for total emissions to peak by around 2030' in China, (OECD, Economic Surveys CHINA, 2015). China's demand for coal is therefore expected to slow down since its use to generate electricity will be subdued as a result of lower power demand growth, 'environmental policies and a rise in non-coal power generation', along with industrial weakness, (Woodmac G, 2015). As a result, China's economic transition away from a coal-fired industry-led model suggests that the coal industry relationship with GDP growth will 'weaken permanently in the long-run', (Woodmac G, 2015).

III. CHINA'S INCREASING CONCERN ABOUT THE ENVIRONMENT

Can China fuel growth without warming the world?

As coal has a significant role in China's energy mix, industry development and GDP growth, the country is undeniably 'the world's largest emitter of greenhouse gases', accounting in 2010 for 28% of worldwide emissions, 77% of it from coal-burning, (Biello, 2010). Therefore, to which extent can China fuel growth without warming the world? China's decreasing patterns of coal consumption, reduced by 2.9% in 2014, have already started to impact global climate. Actually, global emissions of carbon dioxide stalled in 2014, making it the first time in 40 years a reduction in emissions was not tied to an economic downturn, (IEA A, 2015). Nevertheless, 'scientists and officials say [that] China's carbon emissions are likely to keep growing until at least 2025', (Revkin, 2014). Therefore, for the world to stay below the 2°C critical rise in temperature, it has to 'restrict emissions to a little over 700 billion tonnes by 2050' and China would need to bring emissions down to 'zero within ten years of a 2025 peak', which seems hardly achievable according to The Economist, (The Economist, 2013). Besides, there have been suspicions that local officials 'often heavily rely on tax receipts from polluting industries under their jurisdictions', indicating that they may be lax to enforce environmental regulations that would penalize those industries, (Reuters A, 2015). Therefore, although China is tightening climate polices, it is unclear if this will be enough to keep global warming below 2°C. Nonetheless, China aims to reduce CO2 emissions 'per economic unit by 40% by 2020', (Biello, 2010). Encouragingly, China's GDP energy intensity has fallen by about 20% over 2005-2009 and should further go down 40-45% by 2020, compared with 2005, (The Economist, 2013). Yet, as the power generation fleet in China is 63% based on coal, its consumption is not expected to peak before 2030. Indeed, China needs to sustain a minimum level of electricity supply to its population while transitioning to a new energy mix. Paradoxically, while coal-induced pollution seems to be correlated to China's GDP growth, it also costs China lost GDP points.

Measuring Cost of Environmental Damage

The Chinese Academy of Environmental Planning explains that 'the existing accounting system fails to reflect the true cost of resources consumption and environmental degradation', (Jing, 2013). Subsequently, in an effort to report a more environmentally adjusted GDP along with creating a new benchmark to assess local officials, the government launched in March 2004 the 'Green GDP'. The Government released in 2004 the cost derived from pollution, including lost productivity due to health issues, crop degradation and losses from pollution-related accidents: 511.8 billion yuan, or 3.1% of GDP, (Bloomberg B, 2010). In 2010, it was estimated that pollution had caused 1.1 trillion yuan in economic losses or '2.5% of total economic output, but if damage to the ecosystem was included, the losses added up to 1.54 trillion yuan, or 3.5% of that GDP', (Jing, 2013). These estimations suggest that the 'cost of pollution grew more rapidly than GDP in 2010: up 13.7% versus 10.4%', (Jing, 2013). Meanwhile, the World Bank in 2007 valued China's environmental loss to be around $100 billion a year, or 'about 5.8% of GDP', (Bloomberg B, 2010). The difference between the two estimates is likely due to a lack of environmental data but also to resistance from local officials and state-owned polluting industries lobby. Indeed, Green GDP implies a drastic change in the assessment of local officials, switching from exclusively based on hard target such as economic growth to an array of different soft targets, such as environmental damage, sustainability (…). Consequently, while Green GDP is still annually calculated, results are considered politically sensitive and are rarely published. Moreover, the cost of cleaning up the air, water and soil contaminated by coal is estimated to be $965 billion while environmental spending is 'only' 1.3% of GDP, (Huang, 2015 and Economy, 2014). China would therefore need to set up its environmental investment to 2-4% of GDP otherwise, the cleanup won't be able to catch up with the speed of pollution, and may cost 'the Chinese economy half as much in blighted crops, health costs and pollution-related expenses', (Bloomberg B, 2010). Consequently, growing concerns are rising from the inhabitants urging Beijing to implement policies 'to avert an ecological calamity' (Pei, 2013).

Growing Concerns

Coal Pollution Impacting the Environment

Coal combustion releases not only air pollutants (CO2, sulphur dioxide, nitrogen oxides, soot and dust, ozone…) but also toxic solids (mercury, lead, arsenic, nickel, chromium, cadmium…) known as Coal Combustion Waste (CCW) (Gabe, 2015). China has accumulated 2.5 billion tons of coal ash until today, and produces one Olympic-sized swimming pool of ash every 2.5 minutes, (epa.gov, 2015 and Greenpeace East Asia, 2010). While Chinese's legislation on coal ash disposal is very rigorous, studies conducted by Greenpeace revealed disposal sites poorly designed, not secured against dust dispersal or leakage, and subject to collapse enabling pollutants to contaminate the air, the soil, and water. Indeed, when wind is 6m/s, coal ash can spread over 150,000km² (Ailun et al., 2010). In 2006, a nationwide survey of soil pollution was conducted; nevertheless the results were never released. Nationwide water tests evidenced pollutants contained in water surrounding coal-fired power plants well over concentration stipulated in the 'Environmental Quality Standards for Surface Water', 'Standards for Irrigation Water Quality' and 'Sanitary Standards for Drinking Water', (Ailun et al, 2010). The Chinese government conducted a survey on water quality in 2006, revealing that 40% of the water in 10 major rivers was polluted along with 55% of underground water and water quality in 5 out of 9 coastal Chinese bays was poor. While coal industries can use polluted water, farming can't and this water crisis will only be further exacerbated as water consumption for power generation is projected to more than double by 2035, 50% due to coal power generation (IEA, 2015). Food chain contamination is therefore a growing concern and might lead to a major food crisis in China, (Xu, 2014).

Coal Pollution Impacting Health

In 2006, a Chinese study estimated that 'air pollution caused 358,000 premature deaths each year, with an estimated health cost of 152.7 billion yuan', (Jing, 2013). In 2013, another study proved that 'air pollution in China reduces life expectancy by an average of five and a half years', (Economy, 2014). China's 'airpocalypse' is due to particulate matters smaller than 2.5 micrometers (PM2.5) and 72% of PM2.5 are by-products of coal combustion, (Jing, 2014). PM2.5 have been 'recognized as a human carcinogen by the International Agency for Research on Cancer' and 'linked to 670,000 premature deaths', (Jing, 2014). While the WHO has defined PM2.5 safety limit to 10mcg/m3 annually, China has set its own to 35mcg/m3, and yet 'more than 70% of the population is exposed to annual PM2.5 pollution levels higher than this benchmark', (Jing, 2013). In 2014, the New Climate Economy Report estimated that '10% of China's total GDP is lost each year from illnesses related to exposure to polluted air', (Paulson Institute, 2014). Water pollution is alleged to cause 11% of all digestive system cancers along with the increase of other diseases, (Economy, 2014 and Xu, 2014). Therefore, this situation is triggering 'widespread protests that could lead to social unrest if the government doesn't tackle the pollution issue', (Bloomberg B, 2010).

Coal Pollution Threatening the Party

As public awareness rises, 'environmental protests have been one of the leading sources of social unrest for more than two decades', (Bloomberg B, 2010). Indeed, with 51,000 pollution related protests in 2005, 600,000 environment complaints in 2006, 701,073 environment-related petitions in 2010, environmental protests in China grew 30% every year since 1996, (Vines, 2014 and Huang, 2015). Although protests are still local and uncoordinated, they move from rural areas to towns and are becoming harder for authorities to ignore. Moreover, as medias and NGOs are growing more active, the population is increasingly well-informed, less tolerant to pollution and particularly conscious of quality-of-life issues, therefore becoming 'a powerful source of opposition', (Pei, 2013). Public discontent putting the party's social-political stability and credibility in danger urged Premier Li Keqiang to declare in 2014 a 'war on pollution' with policies to address it, (Reuters, 2014). This signals a drastic shift in environmental standards, yet the enforcement of proposed policies remains unsure as the heads of 'large state-owned companies often wield as much power as the ministers', and 'systems of patronage matter more than hierarchies', (The Economist, 2013).

Recent Announcements

In order to ease its saturated market and pollution burden, the central government has designed an array of measures and policies, as shown in below Figure 5. While this chart illustrates the government's unceasing domestic protectionism, it also signals the country's change of behavior regarding its coal-related pollution, through its Environmental policies.

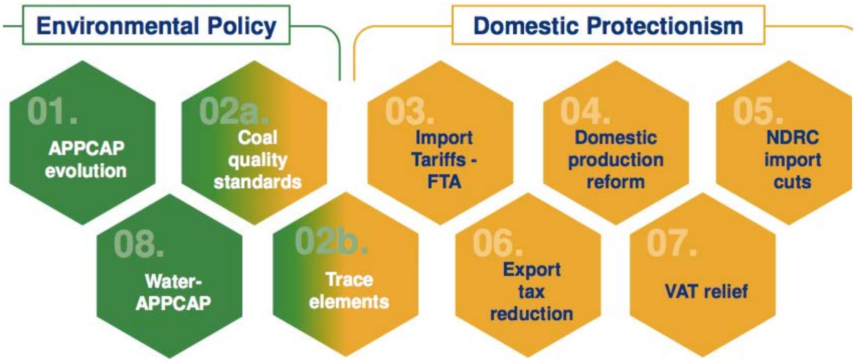

Figure 5: China's Scope of Environmental and Domestic Protectionist Measures (Wood Mackenzie, 2015)

On top of production cuts mentioned earlier, Import Tariffs FTA were implemented in October 2014, resulting in a drop of nearly 50 Mt of 2014 coal imports, which were down 10.9% overall to 291 Mt, (IEEFA, 2015), of which 166.6 Mt was thermal coal, (Wood Mackenzie B, 2015). In May 2015, IHS Energy estimated that overall coal 'imports will be down at least 40 MMT in 2015, and quite possibly by more than 50 MMT below year-ago levels', (IHS Energy C, 2015). At the beginning of the year, the government discounted the export tax from 10% to 3% of the sale price, as an incentive for domestic producers to export more excess output. Such was the case in recent months of China's largest coal-mining company Shenhua Energy Group, (IHS Energy C, 2015), which accounts for 15% of the Chinese coal market, (Intel et al., 2015). 'This does not suggest that there is a massive surge in exports on the way. However, even a small increase in Chinese export volumes will send shock waves through the international market', (IHS Energy C, 2015). Shortly after followed the five-year extension of the US and China Bilateral Climate Agreement in November 2014; a partnership intended to enhance the research and development of clean energy while transitioning to an efficient and low-carbon economy. For China, this re-conduction targets an increase of China's non-fossil share in primary energy consumption to 20% and a peak of its CO2 emissions by 2030, (US-China Joint Announcement on Climate Change, 2014).

In September 2014, the NDRC also restricted all import, production, sale and transportation of coal with low calorific value and of high sulfur and ash content, which thus emits more CO2 per kWh, (OIES, 2014). These measures ban any coal with ash content exceeding 30% and of sulphur content greater than 1.5% for lignite, and 40% and 3% respectively, for Bituminous, (NDRC Commercial coal quality management Interim Measures, 2014). However, the backbone to China's climate change response remains its future CO2 emissions market, which is expected to be operational in 2016, following last year's approval of seven carbon trading pilots carried out in key provinces and cities. Nonetheless, the fact that each pilot differs from one another reflects the heterogeneous regulations and environmental policies across the country and hence, the skepticism that surrounds such practical launch of a nationwide scheme.

While these coal control measures reveal the visible tip of the iceberg, the hidden part resides in the emergence of a potential greener energy-mix, composed of renewable energy, nuclear, gas and Clean Coal Technologies (CCT), which together are expected to help bend the nation's reliance on the dirty fossil, as we will see in the last part.

IV. CHINA'S CHANGING POWER MIX

Power-Mix outlook

China's energy demand is projected to account for 20% of global energy demand by 2040; nevertheless thanks to improved energy intensity, it is likely to peak in 2030. China's electricity demand is projected to grow by more than 140% from 2010 to 2040 and account for 25% of the world's demand. As the economy shifts from heavy industries to services, technologies, and light manufacturing, economic growth is expected to slow down to an annual 5.5%, yet GDP is estimated to rise fourfold by 2040 and account for 20% of global GDP, implying that breaking up with coal won't hinder growth. Nevertheless, China's energy mix should still be dominated by coal in the foreseeable future. Indeed, China's coal consumption is expected to account for 45% of global coal demand, but to peak by 2020, (Exxon Mobil - China Edition, 2015). China's coal demand should mainly be driven up by the power sector and the dirty fuel is projected to still account for around half of produced power until 2035. Although it seems a lot, it is actually a significant reduction of coal use in the electricity mix as coal's share is predicted to decrease from 77% in 2012 to 58% in 2035, all the way down to less than 40% in 2040, (Exxon Mobil - China Edition, 2015). The electricity sector is one of the few that can use any fuel and thus decreasing the share of coal would allow for the expansion of nuclear, gas, renewable, and alternative technologies (BP, 2015). Therefore, if China successfully generates electricity with 50% of zero-carbon sources by 2040, CO2 emissions would peak in 2025, representing a decrease in emissions of 75% per dollar of GDP from 2010 to 2040.

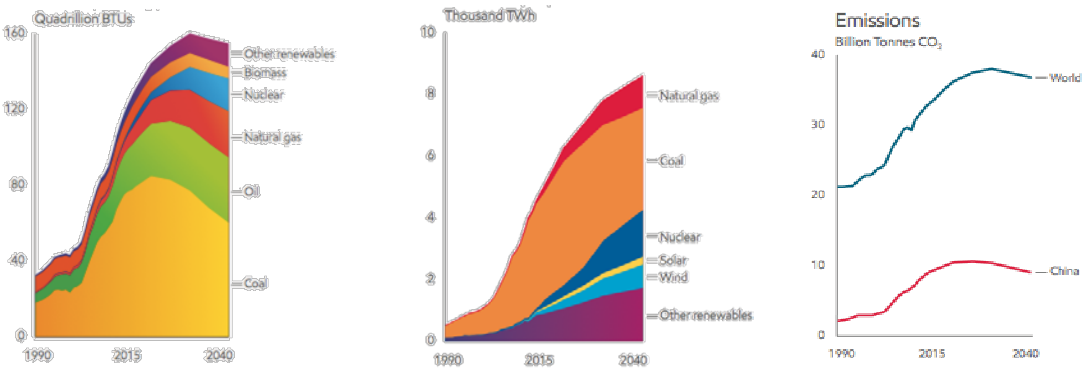

Figure 6: China's Primary Energy Mix, China's Electricity Mix, CO2 Emissions (Exxon Mobil, 2015)

The Nuclear Rush

Nuclear power plants operate like coal or gas-fired power installations, the difference being that the reactor boils water in a clean and efficient manner. Compared to coal, nuclear power produces less waste because the fuel can be used in a reactor for several years. Since 2005, China has managed to rapidly expand its nuclear fleet, benefiting from a major collaboration with France. Today, the country counts 26 operational nuclear power reactors and 24 currently under construction, most of which are equipped with the world's latest reactors, (World Nuclear Association, 2015). Despite unprecedented growth in nuclear projects, the PRC aims to further increase its modest share of 2.4% in the country's current power-mix, (Bloomberg G, 2015), from currently 20 GWe, (Liu, 2015) to as much as 500 GWe of capacity in 2050, (World Nuclear Association, 2015). This significant progression would propel the country to account for 30% of the world's total nuclear fleet by 2050, from a mere 4.5% in 2013, (Hall, 2014).

However, while Mainland's headlong rush to nuclear power remains a major challenge, the country has experienced many delays in project approvals since the Fukushima incident. Indeed, the main drawback to nuclear power is its radiation and unparalleled environmental costs to society in case of accident. Furthermore, China General Nuclear Power Group's chairman He Yu thinks that 'nuclear power is not yet controlled, not yet tamed, not yet safe, and [thus] China cannot take the enormous risks of building nuclear power plants inland', (Yi'nan, 2013). In fact, Wood Mackenzie forecasted last year that 'technology constraints, inadequate infrastructure for uranium-fuel fabrication and disposal [...], and shortages of qualified personnel all mean a more realistic nuclear capacity in 2030 will be 175 gigawatts', (Hall, 2014). A rather reassuring figure if we believe He Yu, who thinks that the country would need at least 150 GWe of nuclear power capacity by 2030, if it wants to meet its peak emission (Liu, 2015).

Wood Mackenzie thinks that such shortage 'will offer opportunities for mining companies to supply huge amounts of additional coal to make up the [nuclear] power shortfall'. Indeed, they believe 'a shortfall of 25 gigawatts would equate to additional annual coal demand of 63 million tons by 2025, falling to 55 million tons by 2030, with gas and renewables filling the rest of the gap', (Hall, 2014). Therefore, Wood Mackenzie forecasts China 'to get more electricity from coal, and less from nuclear, than expected', (Hall, 2014). Furthermore, 'if all 28 gigawatts of nuclear capacity now under construction are completed by 2020, China would reach 45 gigawatts—22% shy of the official capacity target of 58 gigawatts', (Earth Policy, 2014). And this goes without mentioning the additional delays caused by public resistance to inland nuclear expansion as the memory of the Fukushima accident strongly remains. Consequently, this only puts more pressure on the PRC, who is said to invest about 370 USD billion on nuclear power over the next decade, (Bloomberg G, 2015). However, despite China's efforts and investments to rapidly expand domestic nuclear power, the targeted increase of non-fossil fuel share in its energy mix by 2030 is 'only' of 20%, of which the majority is expected to come from renewables. In fact, many reviews, such as the Economist argue that renewables are a lot cheaper, faster, safer and increasingly efficient, (The Economist, 2014), which thus raises China's need to further develop its other alternatives, such as gas, renewables and CCS, as we will cover next.

Coal vs. Gas: Increasing Competition

While coal growth is projected to slow down in the long term globally, 'natural gas is expected to supply about 135% more electricity in 2040 than in 2010, and overtake coal as the largest source of electricity, (Exxon Mobil -Global Edition, 2015). Nevertheless, only very limited coal-to-gas competition has been seen in China, historically. However, with the low price of oil, soften gas prices have spread in Asia in recent months, especially in China. Indeed, while low coal prices are not expected to drop any further, spot LNG prices have fallen as low as 7 USD mmbtu (per million British thermal units) in recent months, (Woodmac A, 2015) and with over 100 million tonnes per annum (Mtpa) of new supply projected for 2020, no sustainable price recovery over 10 mmbtu is to be expected by then, (Woodmac C, 2015). Therefore, the price differential with coal is narrowing close enough to consider a potential rivalry. In certain provinces, gas-fired power generation has already started to be subsidized by the Chinese government, (Ng, 2015). 'And taking a chapter from the US [Shale gas revolution], the Chinese government has started to lend stronger support behind efforts to introduce more gas into the power sector' says the Paulson Institute, (Ma, 2015).

By 2020, the country has set a target to increase natural gas' share in its energy mix from 5% in 2014 to 10%, (Hall, 2014), which would make gas account for 21% of the country's energy demand by 2035, (BP Stats, 2015). According to BP's 2015 Energy Outlook, (BP Stats, 2015), China is expected to contribute 23% of the increase in global gas demand, and reach Europe's 2010 level of consumption by 2030. In fact, the Paulson Institute estimates that China 'will be by far the biggest share of gas demand growth over the next decade', (Ma, 2015). As we can see in Figure 7, expected demand for natural gas in China by 2035 accounts for the most prominent progression, with the highest compound average annual growth rate of 6.6% from 2010 to 2035. Such burgeoning demand would catapult China closer to the leading consuming countries, such as Russia and the US.

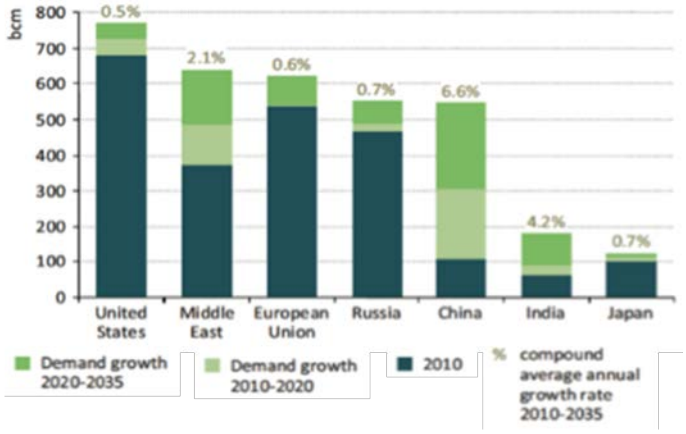

Figure 7: Natural Gas Demand Outlook through 2035 (IEA, 2012)

However, China's electricity demand rush in the near-term is projected to mainly be addressed by coal. Indeed, about 2/3 of the growth in fuel demand for power generation is expected to occur before 2025, (Exxon Mobil - Global Edition, 2015). Therefore, in the sort outlook, coal is unlikely to disappear in favor of gas, which stresses the need for widely available coal. Moreover, even though gas is cheaper to generate power, it remains relatively difficult and costly to retrieve in China due to logistical constraints and complex geology, thus leaving the country to import about one third of its gas, (Ma, 2015). And as shows below Figure 8, BP expects coal's share in China's 2020 energy to only decrease to 62%, from 67% in 2013, as evidence of its intense use in the short-term.

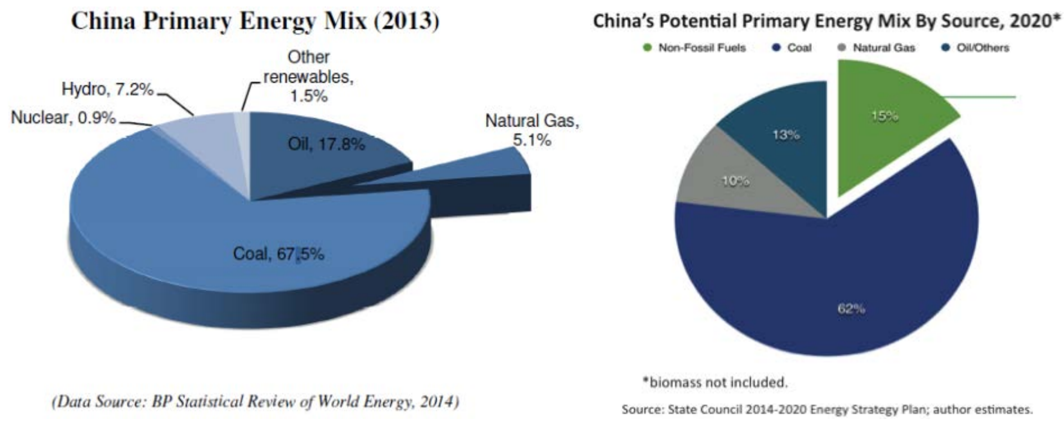

Figure 8: China's Primary Energy Mix in 2013 vs. in 2020 (BP, State Council, 2014)

As a result, even though the country seems to be increasingly concerned about its environment and is seeking to significantly reduce its CO2 emissions, coal seems to be the most adequate and secure solution to meet such energy demand surge in the short run. 'The increasing popularity of natural gas in China will have far reaching consequences [...].

According to experts, switching 1% from coal to gas in power generation would engender carbon savings equivalent to an increase of 11% in renewables share in electricity' said a source, (Nakhle, 2014). However, it is important to bear in mind that while natural gas is 40% less carbon intensive than coal, renewables are carbon-free. And as we will see later, these greener substitutes are expected to contribute a lot more in the long-term to the mitigation of King coal in China, than gas.

Renewables to Ease Coal Dependence

Since China's Premier Li Keqiang has declared war on coal, (Reuters, 2014), 'investment on cleaner sources of energy has risen steeply' with $90 billion invested in renewables in 2014, 'accounting for almost one out of every three dollars spent on clean energy in the world', (Bloomberg A, 2015). China aims to increase the renewable share in its energy mix to 15% by 2020, up to 20% by 2030, (The Economist, 2013). What marks a turning point in the rush for renewable energies in China is that 'investment in hydropower, wind, solar and nuclear facilities increased by 40% between 2008 and 2012', while investment in fossil-fuel power facilities fell from 50% to 25% over the same period, (Mathews and Tan, 2014). Between 2020 and 2030, China is expected to add 1,000GW of renewable energy: 400GW of hydro, 500GW of wind power, and 300 GW of solar (Bloomberg D, 2014). Not surprisingly, China is forecasted to have the world's highest renewable growth between 2013 and 2035 and already has the largest installed base of hydropower, and the second worldwide solar power capacity, as shown in Figure 9. While hydropower accounted for 17% in 2013 China's power mix, the country's second most developed renewable; wind, only accounted for 3% and solar just for 1%, suggesting that wind and solar will offer the most growth potential. Developing renewables is projected to help China ease its coal dependence, improve energy security, reduce CO2 emissions all the while cutting 'energy intensity by 16% in the 2010-2015 period', (OECD, 2015 and 范俊梅, 2015). By scaling up production, the Chinese renewable-energy industry should be able to bend the learning curve and therefore drive renewable technology costs down. Actually, China is already the top manufacturer of wind turbine (Nijhuis, 2014) and the world's lowest-cost producer of solar panels, (The Economist, 2013).

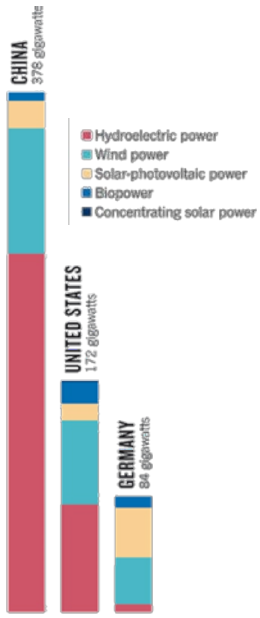

Figure 9: Renewable Power (Matthews and Tan, 2014)

Hydropower

In 2014, China added 22GW of hydro, accounting for 60% of worldwide additional capacity, (UNEP, 2015). This brought the country's total capacity up to 280GW, producing 17% of the country's electricity, (UNEP, 2015). By 2030, China committed to raise total installed hydropower capacity to 420GW, representing 35% of the country's total cumulative renewable power capacity, (Reuters C, 2015). As of today, if China was to fully exploit its already existing hydropower capacity, the output would double from 1 trillion KWh to 2.2 trillion KWh, thus cutting 500 million tons of coal a year, (Reuters E, 2015). Current output is falling short due to the lack of grid connectivity creating 'huge local surpluses that are often literally flushed away', (Reuters E, 2015). Nonetheless, hydropower generation in 2014 increased by almost 20% thanks to better hydrological conditions, (Bloomberg F, 2014). However, hydro has its limits, as China is estimated to exploit 71% of its available hydroelectric potential, therefore making the access to new development sites increasingly difficult, (IHA, 2013). Subsequently, new installations completion in China was down 29% in 2014 compared to 2013, and investments down 21.5%, (UNEP, 2015). Therefore, along with hydro, China would need to develop other renewable sources.

Wind power

In 2014, China installed 23.2GW of wind power, accounting alone for 45% of new worldwide installation, and 31% of global cumulative installations, (GWEC, 2015). This drove PRC's total wind power capacity to 115GW (GWEC, 2015). The nation exceeded its intermediate target of 100GW set in its 2011-2015 'Five-Year-Plan', and is expected to be on track to meet its target of 200GW capacity by 2020 (Buckley, .2014). By 2030, wind capacity is forecasted to reach 500GW, or 41% of China's total renewable capacity, (IRENA, 2014).

In 2014, Chinese cumulative wind power of 115 GW generated 153.4TWh, representing 2.8% of the electricity mix (UNEP, 2015). Comparatively speaking, the EU with a cumulative total of 129GW produced 284TWh in 2014. Meanwhile, the US with a wind power capacity of only 65.9GW produced 1818.8TWh. This brings us to highlight that while China has the second biggest wind power capacity; it 'only' produces 1.33TWh per GW of installed wind power, which is much less than the EU with 2.2TWh or the US with 2.76TWh. This low wind power yield is due to two main factors: bad grid connectivity and high rates of curtailment. Indeed, wind 'idle capacity is the result of the rush to build turbines in the windiest areas of China', surpassing the transmission grid's ability to integrate this unpredictable and powerful surge of electricity, leaving about 1 in every 10 turbine idled, (Bloomberg D, 2014). To remedy these transmission bottlenecks, incentives are deployed to build wind turbines in less-windy areas but nearer demand centers and tests are ran to feed 'surplus' wind-generated power into central and district heating systems, (UNEP, 2015). Thanks to these efforts, 'the rate of grid curtailment decreased slightly in 2014 to 8% nationwide', down 4 points from 12% in 2013 (Buckley, .2014). This lack of grid connectivity implies that it will prove difficult to displace coal by large amount of wind power in the energy mix in the short term. Nevertheless, wind farm per kWH is growing cost-competitive with coal-fired plants, suggesting the potential for wind to help ease coal dependence.

Solar

In 2014, China's solar power additions accounted for 'a quarter of all new global capacity', which brought the Chinese's solar power capacity up 60% yoy (Af.reuters, 2015). China is aiming at reaching a solar capacity of 40GW in 2015 and 'appears on track for meeting that goal' as it already installed 5GW of capacity in Q1 15, or the equivalent of 'France's entire supply of power from the sun', (Wood, 2015 and Bloomberg C, 2015). China's 13th Five-Year-Plan for 2016-2020 aims to reach solar cumulative capacity of 100GW by 2020, (IHS, 2015).

While China has the second largest solar capacity, 28GW, after Germany, 38GW, the PRC only produces 1% of its electricity from it, compared to 7% for Germany, (UNEP, 2015). This inefficiency is due to two factors: locations and grid. Indeed, solar farm tend to be far away from centers of demand and produced electricity is difficult to transport due to inadequate grid capacity. To ease solar development, China has been promoting Distributed Solar Panels (DPV) since 2012. DPV systems are rooftop panels that 'provide at least some of the power they produce to the buildings on which they are located', (IHS, 2015). Around 20% of China's total solar capacity is in the form of DPV, (IHS, 2015). This form of power production is already 'competitive with conventional electricity production'; hence it is projected to play a major role in mitigating the importance of coal in the power mix, (EPIA, 2015). China seems to be aware of this significant potential as the country heavily finances its solar industry ($23.5 billion in 2013), which produced 64% of global solar output in 2014, (UNEP, 2015).

Better Grid, Better Integration

Poor grid connectivity is a major drawback that China would have to address in order to allow renewables in the energy mix. Indeed, the lack of grid flexibility along with the absence of a market for electricity trading seems to be the major obstacles for 'higher penetration of renewable energy in the system', (GWEC, 2015). The State Grid Corporation of China (SGCC) is working to fix this shortage and has announced the investment of '420 billion yuan ($67.6 billion) in 2015', up 24% for 2015 against 14.1% in 2014, (Reuters F, 2015). Indeed, 12 ultra-high voltage power lines are planned for construction to connect China's North and West provinces, where vast wind and solar development projects are taking place; with the central and eastern provinces, where electricity demand is concentrated, (GWEC, 2015). It's estimated that 'China will need to spend more than $4 trillion from now until 2040 to overhaul the way it transmits and distributes electricity', (Bloomberg E, 2014). In this battle to phase out of coal, the new 'power lines will enable the transition from a system based on fossil fuels with clean energy as a supplement to a clean-energy system with fossil energy as a backup', (OIES, 2014).

Renewables aren't enough: Clean Coal Technologies are the Future

The last decade has seen the development and rising importance of Clean Coal Technologies (CCT), which have increasingly established themselves as the main competitor to renewables. Born in the US, CCT, also called Carbon Capture Storage (CCS), is a process applied to coal-fired plants in order to capture carbon dioxide emissions from combustion. The first step of carbon sequestration consists of capturing carbon dioxide from dissociating it in the swirl of stack gases and isolating it. The second and third steps consist of injecting it underground and storing it for thousands of years into porous sandstone formations kilometers below, where it dissolves under pressure. Although CCS is still at an early stage of deployment in China and much R&D is required, (OIES, 2014), the country is already second world leader in such technological advances, behind the US. What has propelled China to that position and what makes the country's strength in undertaking this environmental and energy challenge resides in its ability to efficiently deploy existing technologies, which alone are believed to be sufficient to resolve its polluting problem. Therefore, the country has opened up to Western collaboration and to its private sector in order to accelerate its learning curve. This change of mind-set is key in understanding the country's urge and necessity to import clean coal technologies as a tool to efficiently address its environmental issue. And as is the case with renewable technologies, China's heavy investments are no exception to importing CCS technologies intercontinentally.

Looking at the way coal consumption in China has kept growing these past years, this innovative way of looking at coal in a 'cleaner manner' is therefore crucial. 'Our dependence on coal isn't ending anytime soon. Although renewable energy is expected to boom over the next decade, coal will remain by far the world's top power source', (Mann, 2014). Indeed, the International Energy Agency (IEA) estimates that Beijing will double its ranks of coal-fired power plants by 2040, driving China's carbon emissions to double or even triple, (Mann, 2014). Hence, a lot of energy and climate researchers stress the urge to further develop and implement CCS in China. However, deploying such technology to every existing coal-fired plant in China would be very time-consuming and would not only require a tremendous effort, but also massive investments, without even taking into consideration its development costs. A lot of environmentalists have taken a stance against such technology, arguing that the resources invested in such development would only be at the expense of renewable energy's growth. However, this dilemma has brought China's government to pursue expansions on both solutions, as its alarming carbon problem needs to be addressed with a diversity of solutions. Furthermore, while the time horizon for both prospects is a matter of decades according to scientists, the country has set its peak carbon just 15 years away (2030).

CONCLUSION

As reviewed, it appears that China's coal consumption changing patterns is projected to have far-reaching consequences for tomorrow's international coal scene. Indeed, China's economic boom has slowed down in recent years and has broken the country's ability to absorb global oversupplied coal like it has in the past. In turn, this has led to domestic overcapacity, putting the international coal market in further disequilibrium. This comes amid growing signs of the decoupling of the long lasting relationship between coal and GDP. Additionally, growing pressure from the population has brought the central government to announce structural and market reforms to help ease its coal burden while reducing pollution. This has triggered heavy investments in power research and innovation, which have rapidly brought the country to become a melting pot of technological advances and a testing ground for green energy. While nuclear prospects were tarnished by Fukushima, the fall of gas prices along with renewables are growing more cost competitive with coal generated power, which is expected to further decrease coal's share. While China is working on upgrading its grid to better integrate new sources of power, the country is developing clean coal technologies (CCT), which is estimated to help burn less coal in a more efficient and cleaner manner, enabling to reduce emissions. Paradoxically, it appears that China's coal power generating capacity is expanding as we speak. The reason being that China's fast growing energy demand leaves no alternative but to use every energy source to its fullest potential, including coal. Therefore, while the transition away from coal is expected to happen, coal is still likely to play an essential role in the medium to long-term future in China's energy mix, industry and GDP growth. On the basis of evidence reviewed, even though an irreversible break-up between China and coal is projected to take place, it appears it won't happen before 2040, when coal will no longer be 'King' in the country's energy mix. Consequently, this suggests that China is on a good path to not only meet its climate-change targets agreed under the Bilateral Agreement; but also to successfully phase out of coal definitively in the long-run, all the while without hindering economic growth.

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