Lantau

Pique

In this edition

In this issue of Lantau Pique, we argue that coal use *per se* is not China's major air quality problem. Poor local air quality is not due to how much coal China is using, but rather how China uses that coal. Policies to actively shift baseload coal generation to baseload gas-fired generation in Asia risk being amongst the least cost-effective ways to improve local air quality given available air quality control system technologies, or to reduce carbon emissions, given regional and global fuel market dynamics. Smarter environmental regulation is needed — not specific fuel mix constraints.

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China's Air Quality Problem is Not Coal

China's State Council released the Action Plan for Air Pollution Control and Protection (Guo Shi Tiao) on 10 September 2013, the latest in a series of environmental regulations prompted by China's severe air quality problems.

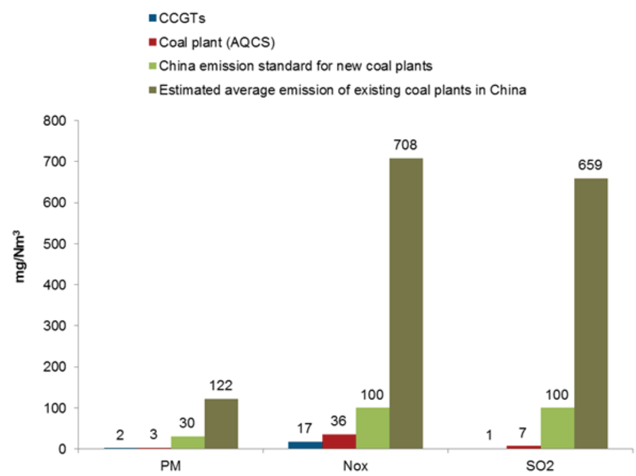
With coal combustion currently contributing more than 60 percent of China's particulate matter (PM) emissions; 70 percent of China's sulphur dioxide (SO_2) emissions; and 50 percent of China's nitrous oxide (NOx) emissions; as well as much of China's carbon emissions, China's use of coal is an obvious and frequent target of criticism.

In response, China's 12th Five Year Plan (FYP) for Energy Development called for coal's share of China's primary energy consumption to fall to around 65 percent by 2015, and the recent Guo Shi Tiao (Action Plan) has stretched that target below 65 percent by 2017 (coal's share was 66.5 percent in 2012). China has also tightened significantly its air emissions standards for power stations, with effect from 2012 for new units, and 2014 for existing units built before 2012.

However, the challenge of improving China's air quality – and specifically how the power sector can best contribute positively to this improvement – is not quite so simple.

In this edition of Lantau Pique, we argue that coal use *per se* is not China's major air quality problem. Nor is it the most cost-effective place to focus China's near-term carbon emission reduction efforts. Newer, highly efficient coal-fired generation units fitted with modern air quality control systems (AQCS) emit about 95 to 98 percent less PM and NOx than the average existing coal-fired power station in China (Figure 1). Existing units retrofitted with the most advanced AQCS can achieve similar performance.

Figure 1: Emissions levels for coal plants with air quality control systems (AQCS), gas plants and existing coal plants



Source: Emission rates from gas-fired CCGT and coal-fired units with advanced AQCS are provided by Burns & McDonnell based on the most advanced available technologies. China's emission rate standards for new coal plant (effective 1 January 2012) are from China's Ministry of Environmental Protection. The average emission rates from China's existing coal plants are based on TLG analysis.

By contrast, shutting down an existing coal plant with "average" emissions and replacing it with a "clean" gas-fired CCGT facility would reduce non-carbon emissions by only a few percent more (in absolute terms) than could be achieved by coal-fired generation with advanced AQCS.

Ultimately, China's local air quality problem is not due to the fact that China depends so heavily on coal, but rather it is due to how China uses coal. Smarter use of coal in facilities with advanced emissions controls; better and more effective regulation and enforcement; better investment and operational incentives; and more efficient system operation are needed for China to improve its local air quality and to slow or reverse the growth of its carbon dioxide emissions.

Four Basic Facts

First, coal-fired generation, even with advanced air quality control systems, is by far the least cost form of electricity generation available to China for large-scale baseload (high-utilisation) application, other than nuclear, which cannot be built as fast and is not without its unique challenges. Natural gas may have its virtues, but, in China, low cost and wide availability are not currently among them. In China, most incremental gas is imported as LNG, or as piped gas from nearby countries such as Russia (proposed) or Turkmenistan (actual), at a cost currently about three times the cost of natural gas in the USA.

Second, the power sector is not the only sector that uses coal. Power sector displacement of industrial coal-fired boilers reduces emissions through enhanced thermal efficiency and more advanced emission control equipment. Consequently, polices that set limits that apply only to specific energy producing or consuming sectors or locations without allowing flexible (trading-based) compliance between or across them can raise costs for no good reason. China seems increasingly alert to this issue, as it stands virtually alone in Asia in its willingness to utilize or experiment with emission trading-based mechanisms.

Third, China's overall generation mix relies on coal-fired capacity providing peaking support. The consequence is often poorer emission control system performance (compared to baseload operations) and a lower thermal efficiency.

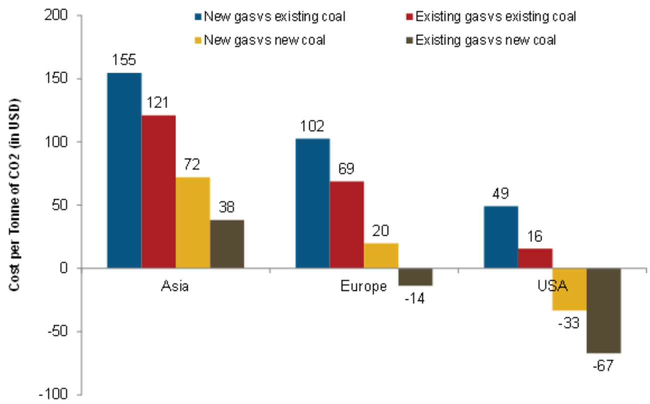
Fourth, incentives matter. China has not yet established a fully consistent and robust system of commercial incentives that align with its environmental objectives.

We discuss these basic facts in turn.

(1) Switching from Coal to Gas

Figure 2 compares the cost-effectiveness of different ways to switch from coal-fired to gas-fired generation in order to reduce carbon emissions.

Figure 2: Break-even carbon cost for gas-fired power plants to replace coal-fired power plants[1]



The comparison takes the additional cost of switching to gas-fired generation rather than coal-fired generation and divides that additional cost by the number of tonnes of CO_2 that would be reduced as a result of the switch.

Figure 2 compares the resulting cost-per-tonne of CO_2 removed across three regions of the world. Because the gap between the cost of natural gas and the cost of coal is greater in Asia, the cost to reduce CO_2 emissions by one tonne in Asia (by burning gas rather than coal) is much higher than in Europe—nearly 50 percent higher when using investment in new gas-fired capacity to displace coal from existing coal-fired capacity. And, the cost is about 260 percent higher when using new gas-fired capacity instead of new coal-fired capacity. In the United States, with cheaper shale gas, the story is even more extreme. Coal is on the losing side of the economic spectrum even before considering CO_2 emissions benefits. New gas-fired capacity is already cheaper than new coal-fired capacity.

China's existing coal-fired power stations would keep on generating (subject to local air quality policies) as long as CO_2 emission reductions are valued at a price less than about USD150/tonne.[2] And China would keep building new coal-fired power stations for base load generation rather than gas-fired power stations for as long as CO_2 emissions are valued less than about USD70/tonne—again given current fuel market conditions.

To date, no country has willingly imposed an explicit price on CO_2 in either of these value ranges. Perhaps such high prices will be needed to reach future decarbonisation objectives, but this will require complex, multi-lateral, and sufficiently binding political agreements – the prospect for which seems to flit between dim and dimmer.[3]

1 Asian LNG prices are assumed to be indexed to oil prices with a slope of 0.1385 (current slope for new LNG contracts in Asia) while gas prices for gas plants in Europe and US are assumed to be set at NBP and Henry Hub respectively.

2 The precise values are always changing as a result of dynamic fuel markets. This is one of the reasons why policies should never set specific fuel mix targets, but rather they should focus on the actual objective of improving environmental outcomes at a cost consistent with the associated value.

3 See for example the perceptive article by Thomas C. Schelling, the 2005 Laureate of the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel, "Some Economics of Global Warming" published.

These very different regional fuel economics scenarios yield very different recommended options, at least if cost-effectiveness matters to anyone, anymore, which it should. After all, the point of doing things that are cost-effective is to avoid wasting financial or other resources. Whatever resources have not been wasted can then be used to do other things that have value. So, before determining that a coal-fired power station is "bad" and a gas-fired power station is "good", the difference in emissions ought to be compared to the difference in cost. It is often the case that a lot more environmental or other "good" could be done with the money saved.

Of course this requires that policy makers develop smarter and more effective policies. But with literally billions of dollars at stake, the challenge of innovative environmental policy is surely worth some effort.

In most of the original visions of how decarbonisation was to work over time, "rich" countries were to pay for the bulk of decarbonisation achieved in "poor" countries. The Clean Development Mechanism (CDM) was an embodiment of this philosophy. In suggesting that Asian countries ought to stop using coal and switch to natural gas even if only as an interim step, then one possible inference is that rich countries would consider contributing financial support for such a switch to be a good investment. Yet, at least right now, would switching China from coal to natural gas for baseload be a good investment in decarbonisation? You might well think so if you do not have to pay for it. And, you should also think so if the social cost of carbon (today) exceeds USD70 dollars a tonne to stop the addition of new coal, (or USD150 to reverse the use of existing coal).

But otherwise, global fuel markets have stacked the deck against natural gas in Asia as a component of a broad decarbonisation strategy at this point in time. That does not mean something won't change in the future, but it does mean that the costs are much higher than elsewhere in the present.

Furthermore, these are sufficiently high carbon values as to suggest the prudence of looking harder for *other* options in Asia, at least for now, given current fuel market price differentials worldwide.

As a thought experiment, consider what might happen if natural gas never takes-off in Asia the way it has recently done in the US. If natural gas simply cannot compete economically with coal in Asia for large-scale baseload operations except at politically unacceptable imputed CO_2 prices, then what happens?

We use the example of a solar farm in Thailand, a country that, for power generation, clearly imports LNG at prices about three times higher than that applicable to current US shale gas. As a consequence, however, the daytime generation output from a solar farm clearly reduces the amount of LNG that Thailand would otherwise require. (In contrast, a similar solar farm in the US would most likely displace generation from natural gas-fired CCGT or OCGT capacity, or possibly even coal-fired capacity depending on the relative price of coal versus natural gas).

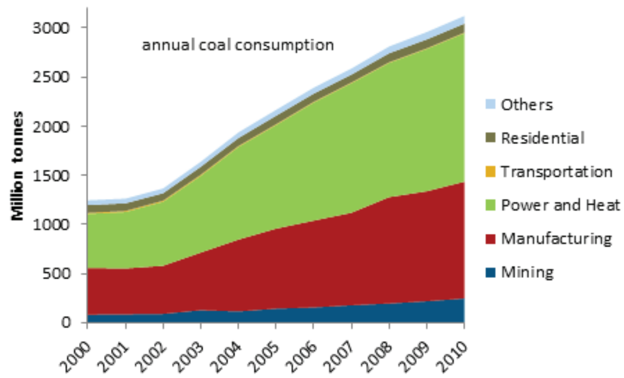
All else equal (including irradiance levels), the fuel displacement savings attributable to our imaginary Thai solar farm is potentially three times that of an otherwise equivalent solar farm one in the US. In the area of renewable energy – where it can displace imported LNG or even oil – Asia currently has an economic advantage in so far as the marginal fuel cost avoided by an RE investment is determined mostly by the cost of natural gas across Asia, the United States, and Europe.[4]

As a result, the imputed value of greenhouse gas emission reductions needed to "swing" a typical renewable energy project from uneconomic to economic is currently lower in Asia. The corollary is that we may finally be moving into a period where renewable energy investment activity could be driven by fundamental economic value rather than on the largesse of a small number of countries. But for this to happen in China or other countries in Asia, it will take policies that commercialise these fundamental economic value drivers. If China and the broader international community want to help this process along, then more attention to fixing international carbon markets is a place to start.

(2) Who (else) uses coal in China?

Currently, China's power sector accounts for only about half of all coal consumption in China (Figure 3), much lower than the United State (93 percent in 2012) and Australia (85 percent in 2011/12).

Figure 3: Coal consumption structure and trends in China

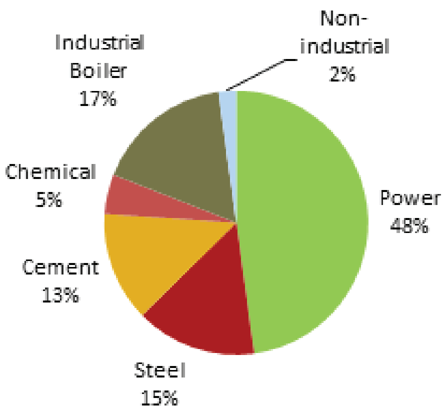


Data source: Statistical Yearbooks from National Bureau of Statistics of China (NBSC)

Manufacturing accounts for most of the other half, with the use of coal a key ingredient in steel, cement and chemical production consuming about two-thirds of that share (one-third overall). Apart from these core industries, however, is a long list of other users that add up to the remaining one-third (Figure 4) (one-sixth overall).

4 The key to Asia's implied RE advantage is mainly the extent to which RE projects displace exposure to local natural gas prices, which are so very different currently, across the globe. Similar issues arise whenever the price of WTI-linked fuels separate from Brent-linked fuels.

Figure 4: China coal consumption by use (2012)[5]



Data source: China National Coal Association, based on data for first 11 months of 2012

These other users are mainly small industrial users that burn coal to produce heat and steam in factories. These small industrial users form a significant source of potential coal-fired emissions reductions, as they are highly inefficient in their use of energy and so are logical targets for replacement by electric power or by more efficient coal- or natural gas-fired combined-heat-and-power (CHP) facilities with modern emission controls.

Consequently, as one of the actions in Guo Shi Tiao, China plans to shut down about 160,000 boilers (about 25 percent of existing industrial boilers) with a total capacity of approximately 510 GW_{th} by 2017.[6] Much of this could be replaced with more efficient CHP capacity. We estimate that China's CHP growth potential ought to greatly exceed the roughly 12 GW annually experienced over the period from 2006 to 2010.[7] The resulting thermal efficiency improvement alone could easily exceed 20 to 30 percent, which given the potential scale of the opportunity is material, reducing both carbon and non-carbon emissions. Further non-carbon emission reduction could be achieved through the application of advanced AQCS.

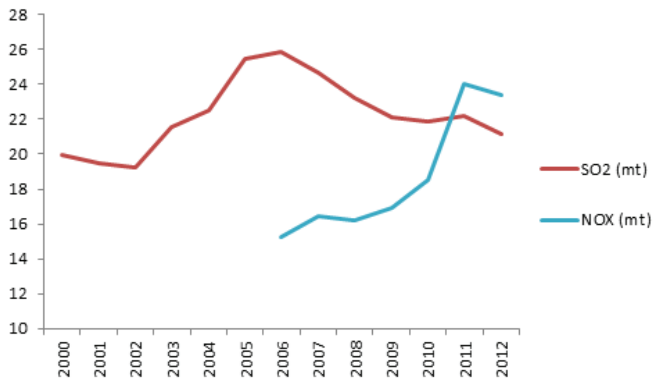
Natural gas is a potential fuel for CHP development, and for greater industrial use. But so too is coal. To put the gas question into perspective, China's coal-fired industrial boilers required about 490 million tonnes[8] of standard coal equivalent in 2012. A switch of just 5 percent of this energy equivalent from coal to natural gas would increase China's natural gas demand by about 20 billion cubic meters (bcm) a year—a significant increase for a gas sector whose total consumption in 2012 was less than 150 bcm.

China's natural gas consumption is constrained by price sensitivity and limited gas supply and pipeline infrastructure. The environmental costs of waiting for gas prices to fall, carbon prices to rise, and gas infrastructure to develop are quite high. This is where coal-fired capacity, smartly regulated, can still make a big difference.

(3) Balancing the system

China has seen a particularly significant increase in NOx emissions in recent years. SO_2 emissions, in contrast, have been trending downward for a decade, a trend that should accelerate with greater enforcement and tougher standards.

Figure 6: Historical SO_2 and NOx emissions



Data source: SO_2 and NOx from China's Ministry of Environmental Protection

As of 2012, less than 30 percent of China's coal-fired power capacity had denitrification equipment installed despite the existence for decades of proven (and ever-improving) emission control technologies. Not surprisingly, therefore, the recent Guo Shi Tiao has made the installation of denitrification systems a requirement for coal fired power plants.

Even where denitrification systems are in place in China (about 95 percent of which employ Selective Catalytic Reduction or "SCR"), NOx emission removal efficiencies range from 50-95 percent. Denitrification efficiency is typically higher when the coal plant is running at the designed load level and flue gas temperature is within specific ranges. When plant load is below certain levels, the SCR system has to stop injection of NH_3 to prevent NH_3 slip (escape), a damaging air pollutant itself.

Overall average utilization of China's coal fleet is around 60 percent, which is low for a baseload technology. Consequently, many of China's coal units frequently operate in ranges that compromise the performance of available denitrification equipment due to the role of these coal-fired plants in providing peaking and cycling capability.

A further source of power sector emission reduction, particularly for NOx, is therefore the potential to rebalance China's power system over time by increasing the proportion of more flexible generation technologies in China's generation mix so that as

5 Non-industrial use includes residential, commercial, agricultural use and mining sector self-consumption.

6 GW_{th} refers to gigawatts thermal, as distinguished from GW, which we use to denote gigawatts electrical (the output after converting thermal energy to electrical energy).

7 http://www.fdi.gov.cn/1800000121_21_46625_0_7.html

8 Nearly 700 million tonnes of raw coal according to China Environmental News http://www.cenews.com.cn/hjzt/ggzt/201305/t20130509_741312.html

China's electricity demand grows, coal-fired units previously used for peaking duty achieve a minimum output level consistent with better SCR performance in removing NOx.

The scope for impact is large, as China's gas-fired fleet is currently very small (only 3.4 percent of total generation capacity).

(4) Incentives Matter

In the past[9] we have argued that China's use of gas in the power sector for peaking and cycling duty has been limited by on-grid pricing policies that do not fully compensate the plant owner for limited but high value operation.[10] This is just one area where the available incentives do not align with the available value proposition. Another area concerns the costs and benefits of denitrification.

Based on typical SCR project costs, NH_3 and catalyst costs, and estimated plant annual utilization hours, the levelised cost of removing NOx for a typical ultra-supercritical 600 MW coal fired plant in China ranges from RMB8.80-RMB12.20/MWh[11] (USD1.44 to USD2.0 per MWh). The current on-grid subsidy for installed denitrification equipment, however, is just RMB10/MWh (USD1.64/ MWh), meaning it is sufficient for only some denitrification systems.

The denitrification cost shortfall might at first seem small, but it is nevertheless an example of how the current tariff system fails to fully reflect the associated costs, and is thus inconsistent with China's stated high priority for air quality improvement. This will have to change.

In other areas, China's National Development and Reform Commission (NDRC) has recently established a new tariff scheme for distributed solar projects (rooftop solar), which pays distributed solar projects a tariff surcharge of RMB0.42/kwh (USD0.07 per MWh)[12] for energy sold to grid companies who are retailers as well (on the condition that project self-consumption is at least 70 percent).

This tariff scheme complements the existing feed-in-tariff for centralized solar power, which has attracted investment in the western provinces. To reduce the financial burden of higher cost renewable energy on grid companies, the NDRC has also increased the renewable energy surcharge grid companies can add to the retail tariff from RMB8/MWh to RMB15/MWh (USD 1.31 to USD 2.46 per MWh).

Finally, the difference between what can technically be achieved with the most advanced AQCS technology and China's announced standards for new and existing units, sets up the question of whether China can further expand its use of flexible trading-based mechanisms. Given the number of units that need to reach compliance and given the diversity of boiler sizes, designs, locations, ages, and so forth, it surely makes sense to expand China's consideration of trading between over-achievers able to install the most advanced AQCS systems and under-achievers whose situations may be limited by the need to provide cycling or peaking operation or where the retrofit of the most advanced control systems.

Conclusion

There is a very long way to go to clean up China's air, and an even longer way to go to reach a sound decarbonisation pathway, but at least for now, there is still plenty of room to use coal-fired technology more intelligently to improve local air quality and slow growth in China's carbon emissions.

Natural gas has an important role to play in China's power system, but it is neither a cost-effective local air quality improvement strategy, nor a decarbonisation strategy for China (or most of Asia), for that matter, at this point in time.

In contrast, renewable energy technologies, – especially those capable of displacing reliance on higher cost fuels – appear to be relatively advantaged in Asia where the displaced fuel is often imported LNG.

Market based regulation with dynamic pricing and flexible arrangements would be well suited to the ever-changing landscape created by dynamic fuel markets. But realistically, such economic regulatory nirvana is still some ways off. In the meantime, much can be done to improve environmental policy effectiveness and to reduce costs by focusing more attention on fuel price differentials between coal and natural gas in Asia as compared to other parts of the world.

The trick to achieving desirable objectives at reasonable costs is to avoid policies, regulations, and constraints that have not first been carefully evaluated in terms of the costs they impose and the benefits they create. China's current focus on reducing coal's share of its overall fuel mix is an example of an outcome-oriented target that appears to ignore the powerful forces of economics.

The current problem is not how much coal China is using, but rather how China uses coal. Smarter environmental policies can achieve more at lower cost. By ignoring irrelevant fuel mix metrics and focusing on the value of reducing emissions versus the cost of doing so, better outcomes are possible.

It's not rocket science. And it matters.

9 See: The Lantau Group, "Will Large Amounts of Domestic Gas Ever Get Into Power?" December 2012.

10 In coastal provinces, due to high gas prices, the commercially viable operation of existing CCGT plants and investment in new CCGT.

11 The low case assumes project costs of RMB80/kW, which is on the low end of denitrification system cost estimates (RMB70-190/kW) and NH3 costs of RMB4,000/tonne, catalysts costs of RMB50,000/tonne and annual utilization hours of 5,500, as used by the NDRC to set on-grid tariffs. The high case assumes project costs of RMB180/kW, the same NH3 and catalyst costs, but lower annual utilization hours of 4,000.

12 Based on: 1 USD=6.1 RMB.

About the authors

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Mike brings over 20 years' experience advising clients on the crucial economic, commercial, strategic and policy matters that continually reshape the global energy sector. Prior to co-founding The Lantau Group in 2010, he headed the Asia Pacific energy & environment practice of Charles River Associates. Before that he was with Putnam, Hayes & Bartlett. He combines rigorous economic analysis with a deep understanding of the major forces that drive change within the energy sector. Mike has an MPP from Harvard Kennedy School and a BA in economics from Carleton College.

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