**EXECUTIVE SUMMARY for the manuscript**

# "Promoting large and closing small" in China's coal power sector 2006-2013：$CO_2$ mitigation assessment based on vintage structure

Shuwei ZHANG, and Xuying QIN

## a) The motivations underlying the research

From the 11th Five-year-plan (FYP), i.e. 2006-2010, China has started to implement the policy of using large scale coal-fired units (larger than 600 MW) with high efficiency to replace the old and inefficient ones (but not reaching the end of their technical life time yet), on the context of seeking better energy efficiency in power sector and achieving the stringent 20% energy intensity decline target. This policy, so-called "promoting large and closing small", resulted in a shutdown of small units about 77 GW in the 11th FYP, and further 10 GW in 2011-2013. The magnitude of shutting down is approximately equal or more than the total capacity of either of the big economies in Europe, like UK, Germany and France.

Much research has been done to account the emission implication as a result of this policy. And these studies commonly found that significant energy saving and emission (whatever local polluters and $CO_2$ emission) reduction achieved, with reference to a constant efficiency level in 2005. However, if considering dynamics of the whole coal power fleet, and the cumulative emission over longer term, it might be a different picture.

Compared to the small power plants built at 1990s, the new-built large plants usually run another 3-4 decades due to sunk capital cost. When lifespan of old plants reached in some near year, new coal-fired plant construction might be not applicable with policy restriction at place and/or competition from other generation options. Under this case, the early-retirement would bring more emission comparing to the counter-factual case, i.e. having the old enough units running until the life time reached. To what extent this difference can be is an unknown but would have a strong implication on the evaluation of the policy.

Motivated by this, the emission mitigation gain from this policy was quantified dynamically in this paper, considering the policy change of coal power in the future. Methodologically a vintage structure of the coal power capacity in China was built.

## b) A short account of the research performed

Firstly, we built the vintage structure of coal power fleet by 2013, based on the statistical indicators on total capacity, its efficiency, and the distribution of the early-retirement units. The efficiency of new additions in each vintage can be calibrated year by year for historic years, and then assumed for the projection period by 2050.

Our scenarios cover two dimensions: existence or not of the coal power limitation policy, and with ER (early-retirement, real case) or not (counter-factual case). In case coal power can increase to meet the growing electricity demand in an unlimited way, we assumed 2kW per capita as a peak level by 2050, and a persist declining share of coal power. In coal limitation cases, all the small units built in 1980-1990s with a life time of 30 years, would exit by 2020 if no early retirement, and after that the remaining capacity of coal is smaller and smaller, due to continuous depreciation and no new additions possible.

Upon the above setting, we can compare the patterns of coal power sector and resulting emission across scenarios. It shows that in 2013, the average age of the whole coal power fleet is as old as 9.7 years in counter-factual noER case, which was lifted to about 8 years in ER case.

Overall, the mitigation gain in 2006-2050, arising from policy intervention by 2013, is positive but as small as 0.1 billion, if coal power can be continuously added throughout the whole projection period. On the contrast, in the case of early-retirement plus coal ban, the new additions in 2006-2013 crowed out the old ones, and persisted for a longer time and brought more emissions. Cumulatively, the ER policy brings 1.2 billion more emission during 2006-2050 if coal ban policy at place from 2020.

Aiming to evaluate this policy in an integrated way, six criteria in the field of environmental economics were adopted to answer the question "good or bad policy".

**c) The main conclusions**

Our paper based on the vintage structure is an assessment on the greenhouse gas related environmental outcome. Generally, long-term environment gain of early retirement policy is not assured, especially for global polluter, i.e. long-lived $CO_2$ emission with stock nature.

Whether long term emission increase or decrease depends on the future climate policy stringency and its impacts on the coal power dynamics. CCS would not be game changer. This implies "asset stranding" risk of large-scale coal power asset again in the future. The cost of implementing future climate mitigation policy might be altered as well.

Energy infrastructure is characterized by long life time, which means a strong inertia, path dependence and carbon lock-in once put into operation. Early retirement policy, intended to unlock existing infrastructures departure from the worse efficiency, in a large likelihood, induce the new lock-in problem due to the units replaced not by clean generation, but again, by the coal power. The whole coal power fleet becomes younger and can live longer.

**d) Potential benefits, applications and policy implications of the work**

To facilitate this research, the vintage structure of China coal power sector was built, although some simplification. To our knowledge, it is the first of several (if not the first) to have such detailed information for China's power sector, can be potentially used in a wider field.

The substantial difference across the scenarios is fundamentally induced by the slow turnover nature of long-lived power capital and the younger coal fleet in the ER case, which would run for longer time and result in more emissions. It needs to be taken into account how to avoid "new lock-in effects" of mitigation policy in the context of climate change concerns. This is the insight that could arise from this study.

At the same time, the paper discussed the role of CCS, whether it could be a game changer to alter the picture shown above. This might be an area for hot debate.