Assessing the Economics of CO₂ Capture in China’s Steel Plant

Xi Liang¹,², Qianguo Lin¹,³, Ming Lei⁴, Qiang Liu⁵, Jia Li², Ailsa Wu³, Muxin Liu²

¹University of Edinburgh Business School, Edinburgh, UK
²UK-China (Guangdong)CCUS Centre, Guangzhou, China
³North China Electric Power Design Institute, Beijing, China
⁴Peking University Guanghua School of Management, Beijing, China
⁵National Center for Climate Change Strategy and International Cooperation, Beijing, China

Abstract

Growing at an average rate of 9% in the last four decades, China is the largest producer of crude steel in the world, contributing approximately half of global steel production since 2013. The lifecycle of the steel manufacturing process contributes approximately 5% of global greenhouse gas emissions. The steel sector has been applying measures to reduce greenhouse gas emissions and to enhance energy efficiency, including blast furnace improvement, enhanced efficiency for blast furnace gas use, the recycling of scrap metal and utilisation of blast furnace slag for cement making, and the reduction of average electricity use in the electricity arc furnace. However, these measures can only result in a marginal reduction of carbon dioxide emissions. Carbon Capture, Utilisation and Storage (CCUS) is the viable large-scale technology to achieve a deep cut of greenhouse gas emissions.

The study reviews a large selection of existing literature about CO₂ capture from steel plants in the world. We found there was as yet no large-scale CCUS industry project in the steel sector. The study also tries to develop a baseline case for applying the state-of-the-art amine post-combustion carbon capture technology for a generic steel plant in China. We developed a simulation process based on ASPEN programming and a cost and financing model for assessing the economics of steel plants. There is generally a lack of projects investigating CO₂ capture from the steel sector in China.

The study reviews existing research on carbon dioxide capture in the steel sector and makes a preliminary analysis for a hypothetical steel plant in China. The study takes a modern steel plant in Zhanjiang, Guangdong as a model for technical and financial analysis. The preliminary findings of the model show an abatement cost at CNY 448/tCO₂. This highly increases to fully decarbonise 2.55% of total steel manufactured in the plant. The impact on the total production cost of the underlying project of building and operating a slip stream capturing 0.5 million tonne CO₂ is CNY21 per tonne steel, when the cost is spread out to the whole production. Although the cost is moderate and there is great potential to reduce it by learning and by scaling up in the future, the current recessional environment in the steel sector could hardly support the additional cost for
demonstrating carbon capture, in particular the net profit margin for Bao Steel was less than 1% in 2015 and less than 3% in 2014.

In regard to financing options, there is insufficient carbon pricing support from the ETS in Guangdong to support a price of CNY448/tCO\(_2\) for the demonstration project. The upcoming national carbon market in China is not expected to have such a high carbon price. The additional cost for demonstrating CCUS could hardly be passed through to consumers unless a new business model or new policy regime is successfully developed. In absence of any support, we found a present value of 1.25 billion Yuan is required to finance the project. We suggest the next step of applied research in steel sector should study a combination of dedicated government and business innovation ideas which request the revenue from auctioning to support the demonstration project, or through border carbon tax adjustment. On the other hand, other innovative and potentially disruptive capture technologies should be investigated. In addition, the study didn’t assess the benefits of improving the purity of the flue gas stream in a coal gas hybrid burning power plant that could actually reduce the marginal cost for carbon abatement.

This report is funded by BHP Billiton-Peking University Industry Carbon Capture Project that supports advanced research for decarbonising the steel sector through CO\(_2\) capture technologies.