WHAT CO_2 PRICE TO TRIGGER CCS INVESTMENT? THE EUROPEAN UNION AND CHINA CASE STUDIES

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Overview

Scientists and international organizations like the IPCC (2014), the Global CCS Institute (2014) etc., present Carbon Capture and Storage as the only current mitigation technology able to drastically decarbonise the power sector[1]. Both developed and developing countries are concerned since their energy demands are still growing and their energy mixes are highly fossil fuel dependent (IEA, 2013).

The EU and China have been chosen to compare CCS costs for several reasons: (1) a CCS slowdown can be observed in the EU contrary to China: the dynamic is thus completely different. (2) Both have introduced or planned[2] to introduce a carbon price; carbon regulation plays a key role in CCS profitability and deployment (Giovanni et al., 2010). Indeed, CCS can emerge endogenously as a cost effective response to carbon restriction. If the carbon price is high enough, decision makers/investors face this choice: either they invest in a CCS power plant to reduce their carbon burden, or they decide not to install CCS and pay for emitted CO_2. (3) One is a developed region, the other a developing country. Power plant costs significantly vary by country, particularly between emerging economies of East Asia like China and the mature markets of North America and Europe. Four explanations can be put forward: lower Chinese labour costs, Chinese economies of scale from building multiple power plants with standardised designs, lower Chinese raw materials/commodities prices (national abundance and state-set prices significantly lower than free-market prices) and less constraining Chinese regulation. Thus in the perspective of minimizing the cost of the ecological transition, it could be more interesting to deploy CCS in China. If it is, it implies some transfers (monetary/R&D…) or policy agreements between the EU and China to sustain and incentivize CCS deployment.

Two questions arise: how much is the extra-cost of a CCS plant in the EU in comparison with China? And then, what is the CO_2 price triggering CCS investments in the EU and in China? By the way, if in one country, there is big gap between the CO_2 price triggering CCS investments and the forecast CO_2 market price, this country could sustain CCS deployment in a low cost country to minimize the cost of the ecological transition.

Methods

To answer these questions, a literature review on CCS public studies was carried out. Currently, there are large discrepancies in the way CCS costs are calculated. Indeed, most studies have their own methodology to calculate some economic data (capital cost, LCoE…) and there is not a set of commonly agreed on boundary conditions such as the discount rate, fuel prices etc. These different sets of techno-economic assumptions can dramatically affect the results (Rubin et al., 2007).These inconsistencies hamper the ability to correctly compare straightforward the cost of different carbon capture options from various public studies.

To address this issue, the following methodology is used: (1) Literature review to select the most recent and relevant public studies. (2) For each public study, the most representative economic data are kept original but updated to current cost level. Two economic data are considered to be representative: the overnight cost and the operation and maintenance (O&M) costs. (3) Calibration of economic data (discount rate, fuel prices, carbon transport and storage costs...) and calculation methodologies (constant annuity investment, fuel cost...). (4) Standardized calculation of the two key metrics to assess objectively the profitability of a CCS power plant: Levelised Cost of Electricity (LCoE) and CO_2 switching price (CO_2 price beyond which a CCS power plant becomes more profitable than another power plant type). In other words, I build a net present value model to calculate the breakeven CO_2 price.

Besides, as techno-economic studies on CCS costs are very scarce in China (Wu et al., 2013), a cost location factor approach (WorleyParsons, 2011) has been applied to OCDE data in order to provide Chinese CCS cost.

Results

The necessity to distinguish intra-technique CO_2 switching prices (CCS coal plant *vs* reference coal plant// CCS gas plant *vs* reference gas plant) and inter-technique CO_2 switching prices (reference coal plant *vs* reference gas plant, reference coal plant *vs* CCS gas plant, etc.) is demonstrated. Indeed, in real life, an investor will compare all the possible arbitrations - coal plant *vs* gas plant *vs* post-combustion gas plant *vs* post-combustion/oxy-combustion/pre-

[1] In 2009, power generation contributed to 40% of total CO_2 atmospheric emissions (IEA, 2012).
[2] Different designs of carbon market are currently tested in five cities and 7 cities are scheduled.

combustion coal plant- and he will choose the power plant type with the lowest LCoE. The optimal power plant type varies with the CO_2 price. This distinction have pointed out that in the EU, contrary to common beliefs, CCS coal plants are not profitable beyond 65 €/tCO_2. Indeed, beyond 65 €/tCO_2, CCS coal plants become more profitable than reference coal plants but they are less cost-effective than gas plants.

Given current power plant costs and international fuel price assumptions (IEA, 2012), a CO_2 price of 115 €/t[3] is required for base-load CCS plants to become the most profitable power plant type in the EU (CCS gas plants) *vs* 35 €/tCO_2 or 45 €/tCO_2[4] in China (CCS coal plants).

As in countries with a high share of renewables, fossil plants are required to be more flexible, the case of mid-load power plants was also considered. CCS plants with mid-load factors are far away to be competitive unless CO_2 prices become particularly significant: 150 €/t CO_2 in the EU (onshore) *vs* 75 (onshore) to 105 €/tCO_2 (offshore) in China.

In 2030, with offshore carbon transport and storage costs, the CO_2 price required to trigger CCS investments is lower: 85 €/tCO_2 in the EU (CCS gas plants) vs 35 €/tCO_2 in China (CCS coal plants). As there isn't a significant difference between this Chinese CO_2 switching price (even lower with onshore transport and storage costs) and the forecast CO_2 price (20 €/t, IEA 2012), no major additional measures are required in China to sustain CCS deployment. By contrast, in the EU, there is a big gap between the CCS CO_2 switching price (85 €/t) and the forecast CO_2 price (30 €/t); significant policy measures to make CCS competitive are thus required.

Conclusions

A methodology has been developed to objectively compare the CCS cost data provided by the most recent and relevant public studies. It has been shown that when CCS costs are not available for a specific region, here China, a cost location factor approach can be applied. Then, it has been demonstrated that there exist several CO_2 switching prices; to be sure that a CCS power plant is the most profitable investment, both intra and inter-technique CO_2 switching prices have to be considered. This paper answers two main questions: (1) If the investment is about base-load plants, what is the CO_2 price required to make CCS plants competitive? Indeed, currently, coal plants are still used in base-load in several European countries such as Poland, Germany (lignite) and China. (2) If the electricity mix has a high share of renewables and if fossil plants are required to be more flexible, what is the CO_2 price that will trigger CCS investments?

This paper gives implications for European and Chinese power plant investors/policy makers. Given the prospective of carbon/fuel/cost prices, on the one hand CCS should be competitive by 2030 in China. Thus, no significant sustain measures are required. On the other hand, in the EU, there is big gap between the CO_2 price that would trigger CCS investments and the forecast CO_2 market price. In the perspective of the cost minimisation of the ecological transition linked with the idea of burden sharing in the GHG mitigation, the EU could also consider the option of sustaining CCS deployment in a low building/operation cost country such as China. This sustain from the EU to China may be shaped in different manners: monetary/technology transfers, R&D agreements (MOU)… The advantage of such collaboration is significant for both countries: developing at least cost the CCS technology will reduce the burden for China and will allow the EU to get back the technology when mature (and thus cheaper). European investors should also consider the opportunity to develop CCS investments and collaborations with China.

References

GCCSI (Global CCS Institute), 2014. The Global status of CCS: 2014. Global CCS Institute, Canberra, Australia.

IEA, 2012. Energy Technology Perspectives 2012. Paris, France.

IEA, 2013. Technology Roadmap, Carbon capture and storage. OECD/IEA, Paris, France.

IPCC, 2014. Climate change 2014: Mitigation of Climate Change. Working Group III contribution to the IPCC 5th Assessment Report - Changes to the underlying Scientific/Technical Assessment. Cambridge University Press, Cambridge, United Kingdom and New York, United States.

Rubin, E.S., Chen, C., Rao, A.B., 2007. Cost and Performance of Fossil Power Plants with CO_2 capture and Storage. Energy Policy 35, 4444–4454.

WorleyParsons, 2011. Economic assessment of carbon capture and storage techniques: 2011 update. Report commissioned by the Global CCS Institute, Canberra, Australia.

Wu, N., Parsons, J.E., Polenske, K.R., 2013. The impact of future carbon prices on CCS investment for power generation in China. Energy Policy 54, 160–172.

ZEP, 2011a. The Costs of CO_2 Storage, Post-demonstration CCS in the EU. Zero Emissions Platform, Brussels, Belgium.

ZEP, 2011b. The Costs of CO_2 Transport, Post-demonstration CCS in the EU. Zero Emissions Platform, Brussels, Belgium.

[3] Offshore transport and storage costs (ZEP's assumptions, 2011a, 2011b).

[4] Respectively onshore and offshore transport and storage costs.