Low Carbon Futures with Carbon Capture and Storage: interactions between technology-push policies and market mechanisms

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Extended Abstract:

The focus of the present study is the interactions of climate policies with markets that place commodity value on carbon. More specifically, the study investigates deployment of one of the currently available climate change mitigation technologies - Carbon Capture and Storage (CCS) - through carbon policies in the context where some of the commercial opportunity may come from the market for utilizing CO_2 in Enhanced Oil Recovery (EOR).

CCS can be defined as a climate change mitigation technology that captures CO_2 emissions from fossil fuel combustion processes and prevents the emissions from being released in the atmosphere (Herzog, 2018). Both components of CCS - the process of carbon capture and the process of storing the captured carbon - can be implemented with the technologies and practices that have been in use for several decades. In this sense, CCS simply uses already existing technologies in a new way. Since the Special Report on Carbon Dioxide Capture and Storage by the Intergovernmental Panel on Climate Change (IPCC, 2005). CCS has been consistently included as a part of technological mix for mitigating climate change in the scenarios by both IPCC and the International Energy Agency (IEA). However, the investigation of the options for CCS deployment has demonstrated a varying degree of interest, being partly influenced by political and commercialization challenges of CCS itself and partly by the changes in the wider energy context.

The study is based on the model of *Carbon Capture, Utilization and Storage in Feedback Rich Energy Context (CCUS-FREC)*. The model is developed to capture some key aspects of the U.S. energy and CCS context, particularly the presence of the market for utilizing CO_2 for EOR. CCUS-FREC is intended to be used to investigate the effects of three drivers that are typically discussed in relation to stimulating more CCS deployment in such context:

- CCS-specific incentive policy similar to 45Q tax credit for EOR and storage
- Carbon policy in the form of a carbon tax
- Higher oil prices (this one is not a policy, but a scenario).

Given a comprehensive structure of the model and its ability to accommodate a relatively high degree of flexibility in its underlying assumptions, CCUS-FREC provides an environment for simulating a variety of policies and policy combinations. The investigated policies include an extension of the currently effective technology-push policy (45Q tax credits) for CCS through mid-century, an expansion of the policy targeted at either storage or EOR, and an expansion of the policy for both CCS destinations yet to a varying extent. The results of simulating an extended set of policy experiments using CCUS-FREC add new dimensions to the current understanding of at least three aspects of CCS deployment.

First, the inferiority of targeting a technology-push policy at CCS for EOR relative to a similar policy for CCS comes in contrast with more of an intuitive focus on incentivizing CCS for EOR, where the market mechanism already places some value on the captured carbon and the policy incentive is expected to cover only the remaining cost increment. Simulating various expansion designs for storage- and EOR-specific CCS separately and in combination shows that without an established large-scale EOR the balancing feedbacks underlying the market for CO_2 as a commodity effectively compensate for higher incentive by exerting downward pressure on CO_2 price and contributing little to additional CCS deployment. The incentive for storage-destined CCS, on the other hand, when large enough, has a direct effect on deployment through the cost offset and an important indirect effect through technological learning and commercialization furthering that spills over to EOR.

Second, the result pertaining to the role of EOR in sustaining rather then accelerating the growth in CCS deployment challenges both the conventional discourse on the potential contribution of EOR to CCS and on the effects of carbon policies related to potential oversupply of carbon and lower CO_2 prices. The contribution of EOR to CCS deployment is typically evaluated based on the market value placed on carbon: the higher the CO_2 price, the higher the contribution of EOR. In this sense, a high carbon tax that leads to the abundance of captured CO_2 relative to what is demanded by EOR productions scale, is associated with minimizing the opportunity to capitalize on the market mechanism to accelerate CCS deployment. Oversupply of CO_2 resulting from strong carbon policy has been only hypothesized by some qualitative assessments (Global CCS Institute, 2011). Simulating CCUS-FREC demonstrates that the situation of oversupply in carbon commodity markets is indeed possible, yet the lower CO_2 prices in the short-run may contribute positively to long-run growth trajectory of CCS by allowing EOR to establish a large-scale production scale. In other words, there is a possibility for a negative price effect (low CO_2 price) in the shorter run to contribute to a positive scale effect (large-scale deployment) in the longer-run.

Third, high oil price is generally expected to stimulate large-scale CCS deployment (GCCSI, 2011; Kolster, Masnadi, Krevor, Dowell, & Brandt, 2017; Beck, 2019). Yet, simulating CCUS-FREC demonstrates that even under the same high long-run oil price scenario a variety of behavior patterns that characterize both CO_2 price dynamics and the trajectory of CCS deployment can be observed. Consequently, the present study suggests that the potential for accelerated CCS growth driven by EOR-related market mechanisms can be realized to a varying degree by different carbon policies implemented in the same oil context.

Low-carbon future with or without CCS is a choice. Low-carbon future with CCS is a more expensive choice in the short and medium-term, but less risky and potentially less costly in the long-term. As the experience of pioneer countries shows, the deployment strategies for CCS are highly context specific. This study emphasizes one widely discussed specific feature of CCS deployment context - the presence of a market mechanism that places the value on CO_2 as a source of cost offset for CCS. While such mechanism has the potential to provide some commercial opportunity, a serious near-term policy aimed at low-carbon future with CCS should consider first and foremost supporting CCS for storage. This intricate dynamics of technological development is an important part of low-carbon future. As the simulations suggest, leaving CCS without support in a future with a strong carbon policy is likely to further battery storage technology and VRE to the extent that leaves no place for CCS in the power sector. Given the likely role of firm capacity even in a VRE-dominated power sector and the uncertainty over the potential of non-power CCS applications to deliver cost reductions through technological and commercialization improvements, such future can be a risky bet if ambitious climate policy is necessitated by the urgency of climate change later in the century.

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