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MODELING A CARBON CAPTURE, TRANSPORT AND STORAGE INFRASTRSTUCTURE FOR THE INDUSTRIAL SECTOR IN EUROPE

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Overview

Various macroscopic analyses such as the IEA CCS Roadmap have indicated that Carbon capture, transport and storage (CCTS) is an important part of the lowest-cost greenhouse gas (GHG) mitigation portfolio [3]. In 2010, the German government announced an 80% CO_2 reduction until the year 2050. This ambitious target requires means far behind efficiency improvements or a switch in fuels, both for the energy and industrial sector.

Industrial sectors, such as iron and steel production, cement manufacturing; refineries and the chemical industry are characterized by a high CO_2 intensity in production. Those emissions are partly based on the combustion of fossil fuels but also on the underlying processes. Yet in contrast to the energy sector, near- or mid-term substitutes to CO_2 intensive processes are not in the offing and modern facilities often work close to the maximum of the physical efficiency.

By applying the CCTS technologies, 80 – 90% of the CO_2 emission could be captured. For the steel and cement industry, capturing could even be accomplished at lower costs compared to power plants. But due to the structure of the sector, which is characterized by a high number of small and regionally dispersed emission sources, complexity of a future CCTS infrastructure would increase, mainly to a longer pipeline network.

Given the limited storage space raises the question, whether the energy sector should also be part of a future CCTS infrastructure at all. This could raise network efficiency du to economies of scale in the pipeline transport, but would sharpen the scarcity of storage potential.

This paper presents a geo-economic model aiming at a microscopic evaluation of the development of a CCTS infrastructure from a German and European perspective. We test the influence of different assumption on the model results e.g., the storage potential, the CO_2 price, and a solely adoption of the technology by the industrial sector.

Methods

The analysis is based on the CCTSMOD-model, which was presented at the IAEE international conference in Stockholm 2011. CCTSMOD is a mixed integer approach of a multi period, welfare optimizing CCTS network model. It can be used to support decisions on implementation of a CCTS infrastructure. The model includes endogenous decisions about pipeline investments, carbon capturing investments, CO_2 ejection and flow quantities based on given costs, a CO_2 certificate price, capacities and emissions for every power plant in the data set. Sources and sinks of CO_2 are aggregated to nodes according to their geographic position. Pipelines can only be constructed between neighboring or diagonal nodes. The distance between two neighboring node can be chosen freely. Thus the model is scalable with regards to the resolution.

The novelty of this approach is that it explicitly takes into account CCTS in the industrial sector. We have the option to combine the analysis of CCTS in the energy sector and the industrial sector, but the model can also be confined to the industrial sector only. Various scenarios can be developed that sketch out a precise methodological basis for decision-making in the industrial sector, that has so far been largely ignored by scientific analysis and policy.

Preliminary Results

Previous results have shown that the industrial sector acts as a first mover for the CCTS adoption [5]. In a welfare optimizing setting, trunk line pipelines are built in early periods which are also used by the energy sector in later periods. A cost-optimal CCTS infrastructure can be described as a number of regional networks evolving around distinct storage facilities with no connection between the networks. Results also reveal that even under high CO_2 prices only parts of the industrial and energy sector would use the technology.

An emission reduction of 90% is achievable if the industrial sector is forced into applying CCTS. For Germany, this requires construction of 10.000 km pipelines (worth 2 bn €) and investment into capture of more than 6 bn € to store an annual amount of 50 mil t/CO_2. This highlights the increased complexity of a solely industrial application of the technology where the focus is not longer set on capture, but on the transport infrastructure.

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