Roman Mendelevitch[1], Pao-Yu Oei[2], Andreas Tissen[3], Jens Weibezahn[4]

CO_2 HIGHWAYS FOR GERMANY AND EUROPE – MODELING A PIPELINE INFRASTRUCTURE FOR CCTS –

Technische Universität Berlin, Workgroup for Economic and Infrastructure Policy
Straße des 17. Juni 135, 10623 Berlin, Germany
+49-30-314-27500
[1]rm@wip.tu-berlin.de
[2]paoyuoei@gmail.com
[3]ati@wip.tu-berlin.de
[4]jew@wip.tu-berlin.de

OVERVIEW

Various macroscopic analyses such as the IEA CCS Roadmap have proven that Carbon capture and storage (CCS) is an important part of the lowest-cost greenhouse gas (GHG) mitigation portfolio.[3] This paper presents a spatial engineering-economic model aiming at a microscopic evaluation of the development of a CCS infrastructure from a German and European perspective.

Recent Carbon capture, transport and storage (CCTS) models mostly concentrate on the US. The Global Energy Technology Strategy Program (GTSP) examined the development of the CCTS technology for fossil-fuel-intensive electricity generation regions of the USA. The sensitivity analysis of different CO_2 price paths provides evidence that storage site characteristics and their spatial allocation are the most significant factors for the deployment of a CCTS infrastructure [1]. In a more recent modeling attempt Fritze [2] investigated aspects of infrastructure finance and the provision of publicly developed CO_2 trunk lines. The main findings suggested that public provision would not be welfare optimal; however since economies of scale could not be implemented in the model results can be doubted. Middleton and Bielicki [4] developed a scalable cost minimizing CCTS model for the Californian energy sector. It is able to compute a cost optimal development of CCTS taking into account infrastructure-based economies of scale.

METHODS

The 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 nodes can be chosen freely. Thus the model is scalable with regards to the resolution.

RESULTS

A sensitivity analysis of the relation between the deployment of the CCTS technology and the underlying CO_2 price path provides evidence that CCTS technology only becomes economically beneficial when the CO_2 price rises by at least three Euros each five year period, starting from 15 Euros in the year 2010. Furthermore an increase of five Euros per five year period goes in line with IEA Blue map Scenario forecasts regarding the evolvement

of the CCTS network in the European Union. It results in a pipeline network of 230 km in Germany in the year 2015 and up to 4400 km in the last year of observation 2050. Thus an average annual storage of 200 Mt, or 34% of the total emitted CO_2 from large point sources in Germany, is made in onshore saline aquifers. The respective overall CO_2 abatement costs for all emitters sum up to 238 billion Euros over all model periods from 2005 to 2060.
Furthermore the effects of political resistance against onshore CO_2 storage on the evolvement of the CCTS network in Germany were examined. Analyzing the total effect of this scenario, an increase of the total CO_2 abatement costs by 11 % from 238 to 264 billion Euros can be observed. The results show that in that case nearby offshore saline aquifers can serve as temporary solution but are only cost-efficient once the CO_2 certificate price exceeds 50 Euros per ton. Participating in a joint project for CO_2 storage in some of the gas fields more distant from the German coast in the North Sea is only to be advised when the certificate price exceeds 67 Euros.

CONCLUSION

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. Despite the discount rate on investments pipelines tend to be constructed with higher capacity than initially needed due to economies of scale coming with rising CO_2 flows in later periods. Due to their spatial availability and their most efficient cost capacity ratio onshore saline aquifer are computed to be the only type of storage sites used for CCTS in Germany. Offshore aquifers only become an option for German CO_2 mitigation schemes if the CO_2 price exceeds 50 Euros per ton of CO_2.
Further research is needed on the field of strategic behavior regarding the locally scarce resource of CO_2 storage capacity. A game-theoretical approach should be implemented simulating the behavior of the major players on the German energy sector (EnBW, E.ON, RWE, Vattenfall). Furthermore a European expansion of the model will be able to simulate interdependencies and economic effects of an integrated European CCTS infrastructure in comparison to isolated developments in the respective countries. The implementation of stochastic elements for the success of early CCTS projects will improve the reliability of the model.

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