THE DECISIVE ROLE OF THE CARBON STORAGE POTENTIAL IN THE DEPLOYMENT OF THE CCS OPTION

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Overview

Over the past decade and while in May 2013 CO_2 concentration in the atmosphere reached record high of 400 ppm, Carbon Capture and Storage (CCS) has increasingly been dealt as a possible, not to say an expected, solution to achieve CO_2 emissions mitigation objectives. But CCS technologies generate persistent controversies, not only concerning the significant and uncertain costs that this technology requires and the too low level of investment, but also concerning risks of storage for environment and human health that question the social acceptability and the appropriate place of CCS technologies within the portfolio of GHG abatement strategies. Especially, the potential of deployment of CCS is highly connected to the potential of carbon storage. In ETSAP-TIAM (and TIAM-FR), the assumed high level of this potential is not a constraint for the development of this solution but data are not always in line with literature. The question of the location of the sites, in the sense of an offshore and onshore distribution, also impacts the structuring of the CCS sector, in terms of availability, acceptability and cost. The purpose of this analysis is to estimate the CO_2 storage capacity at a regional level based on updated data from available literature and discuss the impact of this potential on the development of the CCS option in a climate context. Then, different scenarios on the availability of storage sinks (particularly offshore/onshore) were conducted in TIAM-FR to evaluate whether CCS deployment is limited.

Methods

This analysis is developed with TIAM-FR, a bottom-up model describing the world energy system in great detail of current and future technologies expressed by region and sector. TIAM-FR, of the ETSAP-TIMES family model, is a geographically integrated model, with 15 world regions, on the time horizon from 2005 to 2100. We first realized a state of the art of regional carbon storage potentials to propose updated and new data in the model, and particularly, we add a new distribution between onshore and offshore potential as regards deep saline aquifers. More precisely, storage capacities data are classified according to the storage site type, i.e. deep saline aquifers, coal basins, depleted oil and gas fiels, and so, for all type, to the storage site location, i.e. onshore and offshore. Many sources have been used as the North American Carbon Storage Atlas (2012), the United States Carbon Utilization and Storage Atlas – DOE & NETL (2012, 4th edition), IEA, Dooley et al. (2005), Hendricks (2004), Ecofys (2004) ZEP (2010), McKinsey & Compagny (2008), USGS World Petroleum Assessment 2000, and various specific national sources. A brief study was done to look into the storage capacities assumed by other Energy models (as MERGE, REMIND, POLES, E3MG, TIMER). In a second step, even if capture is the most important part of the CCS cost, contributing 80% or more, we updated the costs of carbon storage and transport. And due to the new classification for saline aquifer, onshore and offshore, we proposed different cost according to the location of the site. Finally, we realized an impact analysis of these new potential by comparison with previous data to discuss whether CCS deployment can be limited by assumed storage conditions.

Results

Currently, very few countries have done an assessment of their CO_2 storage capacity. Moreover, the countries who did, used their own set of assumptions and methodology which upon aggregating does not match properly with the global potential estimates. In this study, we selected the global data from IEAGHG (2009b) and then we classified it into regions and storage site by using other sources as, for example, Hendricks; United States Geological Survey (USGS), Total Petroleum System (TPS) and specific national or industrial data. Classifying storage data according to their type and location will provide a deeper insight regarding CCS deployment feasibility under climate constraints. Storage potential study was done for 96% of known oil reserve in the world and 60% of the gas fields, this is the most suitable given data constraints. Investigating the storage capacities in each reservoir require a huge investment of time, capital and manpower. In most of the regional studies research is performed for selected sites and then extrapolated for the whole region based on assumptions. Aggregating the data from such sources has two major problems: data for each country in that region may not be available, due to different assumptions and methodology in each study the aggregated data may not lead to correct storage capacity estimates. Storage capacities estimated for each country using these references may not be accurate as many small storage sites have been neglected but an uniform methodology has been applied which gives reliable estimates for each region that can be compared and aggregated. For proper planning of the CCS projects, it is important to have the storage potential estimates along with the timeline of their availability. Storage in depleted oil and gas fields can only be started once the production is ceased. Source-sink matching is also an important factor in CCS projects-planning. This issue is analyzed in the literature we have used, but it is not included in this study. However, huge potential of storage lies in the saline aquifers and there are not this problem of source-sink matching as in the case of Oil and Gas reservoirs. Pipeline installation is a labor intensive job. The cost of pipeline and labor varies in different regions, so capital cost and O&M cost differ for each region. CO_2 transport costs estimates used previously in the TIAM-FR model are bit higher than the transport costs reported in the references used in this study and there is no difference between the cost of onshore and offshore transport. We used the ZEP (2010) estimates of storage costs for a realistic approach or McKinsey & Company (2008) estimates for a conservative approach. Though these references conclude that it is very difficult to generalize the cost of CO_2 transport as it is project/site dependent, it is convenient to have an average estimate. Then, we investigate different scenarios according to the regional carbon storage potentials, the regional costs of transport and storage, and a possible allowed location of carbon storage, offshore and onshore.

Conclusion

Giving the challenge of mitigating the effects of climate change and so reducing the level of carbon emissions, this study highlights the role of carbon storage in the development of CCS which, currently, is the only technology that can capture at least 90% of the emissions from the world’s largest CO2 emitters. This is particularly important in a world where coal is not yet an outdated and disappearing source of energy. Even if the first challenges that needs to be addressed is the large-scale developpement of CCS, this option can not throw off the need to store captured carbon or develop a chain of applications where the carbon would have an economic value. This study focuses on the carbon storage side and discusses, through detailed and updated data on storage potential and cost, whether the potential may be a limit to the development of CCS.

References

Azar, C., Lindgren, K., Larson, E., Mollersten, K. (2006). Carbon capture and storage from fossil fuels and biomass – Costs and potential role in stabilizing the atmosphere, *Climatic Change*, Volume 74, Issue 1-3 (47-79).

Bachu, S., Bonijoly, D., Bradshaw, J., Burruss, R., Holloway, S., Christensen, N-P. & Mathiassen, O-M. (2007). CO_2 storage capacity estimation: Methodology and gaps. *International Journal of Greenhouse Gas Control*, 1, 430-443.

Bradshaw, J., Bachu, S., Bonijoly, D., Burruss, R., Holloway, S., Christensen, N-P. & Mathiassen, O-M. (2007). CO_2 storage capacity estimation: Issues and developments of standards, *International Journal of Greenhouse Gas Control,* 1, 62-68.

Edenhofer O., Knopf B., Barker T., Baumstark L., Bellevrat E., Chateau B., Criqui P., Isaac M., Kitous A., Kypreos S., Leimbach M., Lessmann K., Magne B., Scrieciu B, Turton H., van Vuuren D. P. (2010). The Economics of Low Stabilization: Model Comparison of Mitigation Strategies and Costs, *The Energy Journal*, Volume 31, Special Issue.

Friedmann, S. J., Dooley, J. J., Held, H. and Edenhofer, O. (2006). The low cost of geological assessment for underground CO_2 storage: Policy and economic implications. *Energy Conversion and Management*, 47 (13-14), 1894-1901.

Hendriks, C., Graus, W., van Bergen, F., (2004). Global carbon dioxide storage potential and costs. Report by Ecofys in cooperation with TNO. EEP-02001 by order of the: Rijksinstituut voor Volksgezondheid en Milieu (Dutch National Institute for Public Health and the Environment).

Knoope M.M.J., Ramirez A. and Faaij A.P.C. (2013). A state-of-the-art review of technico-economic models predicting the costs of CO_2 pipeline transport, *International Journal of Greenhouse Gas Control,* 16, 241-270.

Michael K., Arnot M., Cook P., Ennis-King J., Funnell R., Kaldi J., Kirste D. and Paterson L. (2009). CO2 storage in saline aquifers I – current state of scientific knowledge, Energy Procedia, Volume 1, Issue 1, 3197-3204.

Michael K., Allinson A., Golab A., Sharma S. and Shulakova V. (2009). CO2 storage in saline aquifers II – experience from existing storage operations, Energy Procedia, Volume 1, Issue 1, 1973-1980.