European Scenarios of CO_2 Infrastructure Investment

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Executive summary

In this paper we present a model analysis and interpretation of the potential role of Carbon Capture, Transport and Storage (CCTS) to support the EU energy system transition to meet the emission reductions goals that are consistent with an international goal of staying below 2°C of global warming. Our hypothesis is that CCTS - contrary to the dominant belief until recently - will at best be a niche technology applied in regions with highly conducive conditions, e.g. parts of the North Sea, but that due to its cost disadvantages and recent setbacks in many EU countries, will not contribute significantly to overall EU energy system decarbonization.

The starting point for our analysis is the dichotomy between the high hopes that were put into CCTS - and that are still alive in some communities – and the realities documenting that not a single full-scale CCTS project with long-term geological storage has yet been realized worldwide. At the same time, CO_2 transport infrastructure projects have been removed from the list of critical infrastructure projects of the EU. Furthermore, the London Protocol still prohibits the movement of CO_2 across marine borders for the purposes of geological storage. Facing these adverse developments, academia as well as technical reports have become more balanced or even critical with respect to CCTS deployment.

We apply the mixed-integer model CCTS-Mod to examine the deployment of the CCTS technology in Europe using different regional foci. We study the effects of different CO_2 price paths and the sensitivity of results to assumptions on variable and investment cost for CO_2 capture, to the availability of CO_2-enhanced oil recovery, and to limited storage availability.

Our moderate CO_2-price scenarios assume a CO_2 price of 50 €/tCO_2 in 2050 which triggers hardly any CCTS development in Europe. Additional revenues from applying CO_2-enhanced oil recovery (CO_2-EOR) in the North Sea lead to an earlier adoption of CCTS starting in 2025 independent from the CO_2 certificate price. The lifespan of most CO_2-EOR operations is expected to be around ten years. It is followed by conventional CO_2 storage in nearby depleted hydrocarbon fields and saline aquifers once the CO_2 certificate price exceeds the sector-specific thresholds to cover variable costs of carbon capture. Generally, the use of CO_2 for EOR projects is criticized by environmental organizations, as the overall CO_2 mitigation effect is negative considering the CO_2 content of the additional extracted oil.

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Our more stringent climate scenarios aim at an 80% GHG reduction until 2050. The resulting CO_2 price of 270 €/tCO_2 in 2050 pushes all EU-ETS industry and energy sectors to use CCTS at some point. It is, however, the iron and steel sector that start deployment as soon as the CO_2 certificate price rises above 50 €/tCO_2 in 2030. The cement sector follows some years later at a threshold of around 75 €/tCO_2. It is only with CO_2 certificate prices exceeding 100 €/tCO_2 that CCTS becomes lucrative for the electricity sector. Sensitivity analysis shows that the future development of a CCTS infrastructure is more sensitive to its variable costs than its investment costs. Due to high public resistance, the use of onshore storage sites is unlikely in Europe. Consequently, transport distances and associated costs increase. The resulting CO_2 transport network required to connect emission sources and storage sites across Europe would comprise of up to 45,000 km of pipeline and store up to 1,000 MtCO_2 per year.

Taking into account the realities that confront CCTS in the EU, political and public opposition has left only a handful of countries that still consider building CCTS in the medium term. A 20% CCTS penetration rate in the European power sector as calculated in the *DNNU_80%* scenario in 2050 thus seems more realistic. Concentrating on Denmark, the Netherlands, Norway and the UK, this scenario shows an intensive use of the combination of CCTS and CO_2-EOR especially in the UK and the Netherlands. However, a lack of economies of scale leads to increasing average costs, once the CO_2-EOR-fields have been exploited: CO_2 storage costs increase by more than 30% in 2040 while transport costs even double compared to costs observed with a European-wide CCTS application.

The mirage of a Pan-European network for CCTS in the EU-ETS industry and energy sectors, as envisioned in some long-term scenario projections, seems out of reach at present due to a combination of a lack of economic incentives as well as too little political and public support for CCTS as a mitigation technology. Further research, however, is needed to evaluate the effects of the newest European reforms (e.g. the reform of the EU Emissions Trading System ETS) as well as national regulations (e.g. emissions performance standards (EPS) and contract for differences (CfD) in the UK) on the development of CCTS.

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