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Socio-economic impacts of low-carbon power generation portfolios: Strategies with and without CCS for the Netherlands

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HIGHLIGHTS

- We compare GHG mitigation policy including or excluding CCS on socio-economic impacts for the Netherlands.
- We simulate these policy options in a global multiregional Input-Output Model with detailed bottom-up technology data.
- Economy-wide differentials between these mitigation policies are small for Employment, GDP and Imports.
- Notable impacts are found for the energy sector and some upstream sectors (natural gas, construction).
- This pattern shows to base a choice on macroeconomic impacts is hard and it will affect strong and vested interests.

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ABSTRACT

Carbon Capture and Storage (CCS) could be an interesting option to mitigate greenhouse gas emissions in the Netherlands. This study compares a mitigation strategy for the Dutch power sector that includes CCS to one without on several socio-economic indicators. In particular, we calculate incremental gross value added (GVA), employment and import dependency impacts of two such low-carbon power production portfolios for the Netherlands. We combine technology specific techno-economic bottom-up data with a macro-economic multi-regional Input-Output-Table containing high sectoral detail. For the total economy, we find the differences between these scenarios to be small. Still, gross value added, and employment are lower under the CCS-inclusive strategy, while import dependency is higher. For the power sector, the differences between the scenarios are, however, considerable. Furthermore, our analysis shows that also for other sectors the differences between the scenarios could be large. For instance, a CCS-exclusive strategy leads to considerably higher GVA and employment in domestic construction services, while the CCS-inclusive strategy comes with considerably higher GVA and employment for natural gas mining and related upstream sectors.

1. Introduction

The Netherlands aims to reduce greenhouse gas (GHG) emissions in 2030 by at least 40% compared to 1990 levels [1]. Recently, the Netherlands also signed the Paris Agreement on Climate Change (COP21) [2], with the overall objective to keep global temperature rise well below 2 °C and possibly even as low as 1.5 °C. The energy agreement for sustainable growth for the Netherlands [3] at the same time states that fossil fuels will remain an important energy source over this period. This means that carbon capture and storage (CCS) will thus be a possible interesting technique, possibly as transition technology. Also, simply based on costs, CCS could be an attractive mitigation option in the Netherlands, given the estimated storage potential in depleted gas and oil fields for about 2.2 Gt of CO_2 [4].

The Netherlands has participated in CCS research for many years [5]. However, socio-economic impact analyses at the macro

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and sector-level are rare. Studies comparing different alternative strategies to reduce emissions are even more exceptional. A study by Koornneef et al. [6], gives a rough range of cumulative gross value added (GVA) and employment effects that could be attained by Dutch companies over the period 2010–2050. However, that study does not directly compare the implementation of CCS to a strategy relying exclusively on alternative technologies. Such a comparison of strategies with and without CCS can be found in Koopmans et al. [7], who present a cost-benefit analysis of welfare effects for these scenarios, based on key figures from existing literature. They conclude that there are no significant differences in overall cost and benefits between the two strategies for the Netherlands. While providing an interesting insight in possible aggregate socio-economic impacts of implementing CCS in the Netherlands, their study does not consider the sectoral, national and international trade interdependencies of the Netherlands.

In the present study, we implement the power production technology portfolios for the two strategies from Koopmans et al. [7] - where an ambitious climate mitigation target was assumed (80% emission reduction in 2050 compared to 1990) - and explore in more detail the socio-economic impacts of using a CCS-inclusive or renewable based strategy for the Dutch power sector. We go beyond the work by Koopmans et al. [7] by using a Multi-Regional trade-linked Input-Output-Model (IO-Model). Such models allow us to gain detailed insights into the upstream economic effects at the sector-level [8,9]. The high sectoral detail and international trade links specified in our IO-Model, help us trace the impacts upstream through the intermediate deliveries.

Our study includes the construction of a detailed economic representation of power production in the Netherlands, consistent with plausible technological modifications until 2030. This is done by combining techno-economic data, which is country and technology specific (levelized cost of electricity (LCOE)) with the information derived for a Multi-Regional MRIO database[1] to specify the projected input structure of power production in the Netherlands in 2030. Next, we calculate gross value added (GVA), employment and trade effects for a CCS-inclusive and a renewables only power production mix in the Netherlands. We compare the two scenarios based on these indicators on the aggregate as well as on the sector-level.

In this paper we contribute to the literature in three ways. In several studies the impact of CCS on GVA and employment has been assessed (e.g. [6,10–13]). However, in none of these studies CCS is considered as part of a portfolio, neither are the impacts compared to those in an alternative climate mitigation strategy. This study addresses these shortcomings.

Secondly, we compare the impact of a mitigation strategy with and without CCS for a small open economy that relies heavily on (imported) coal and gas fired power production. Earlier studies have looked at CCS in large, relatively closed economies such as the US [14], Germany [15] and China [16]. Others research indicates, however, that including CCS can have an impact on the import dependency of a country (e.g. [17,18]).

Our third contribution lies in the application of a multiregional Input-Output model for the comparison of two distinct future mitigation portfolios. In several very recent studies the IO-Method has successfully been applied to assess the impacts of gas taxes and fuel subsidies [19], feed-in tariffs [20], deployment of low-carbon technologies [21] and implementation of an energy efficiency program [22]. To the best of our knowledge this study is the first to apply this method to the diffusion of CCS in the Netherlands.

In our results, we look at the costs and benefits for specific sectors such as gas mining, fossil fuel imports, and construction. These costs (or benefits) for each sector could come in the form of lower (higher) economic activity (GVA) and lower (higher) employment. Of course the impacts on trade depend crucially on the import dependency of sectors. The results also allow us to discuss impacts on energy imports and consequently energy security. In this context, it should be noted that the Netherlands will have to reduce natural gas production anyway – and thus will have to evaluate strategies with alternative technologies or increased imports. That could make energy security an issue in the comparison as CCS relies more on fossil fuel for energy production.

Our paper proceeds as follows: In Section 2 we describe the scenarios and method used in this paper. We present our results in Section 3. Then Section 4 provides the outcomes of our sensitivity analysis. Finally, we discuss the research in Section 5 and draw conclusions in Section 6.

2. Scenario's and methodology

2.1. Overall approach

To explore economic impacts of CCS use in the power sector we calculated GVA, import dependency and employment for two potential future low-carbon power production portfolios in the Netherlands, using the Multi-Regional Input-Output database EXIOBASE.[2]

The analysis consists of four steps:

1. Scenario selection.
2. Modification of power input vectors.
3. Scenario implementation in the Input Output-Table (IO-table) framework.
4. Calculation of economic indicators.

In step one we adopted two hypothetical scenarios for power production in the Netherlands for 2030 from Koopmans et al. [7]. Both scenarios achieve the same mitigation target in 2050. The most important difference between the scenarios is that in one CCS is excluded from the mitigation options. We chose the year 2030 because CCS can only start to play a considerable role around that time. Details about the scenarios are given in Section 2.2 below.

In step two we aggregate the EXIOBASE IO-table to three regions, (i.e. the Netherlands, remaining Europe[3] and the Rest of the World (RoW)) and modify the power sector input coefficients to represent power production technologies viable in 2030. The latter are based on supplementary techno-economic cost and performance data and more details on this step are provided in Section 2.3 below.

In step three we implement the scenarios into the 2007 IO-table, by changing the output shares of different power production technologies according to the 2030 portfolio shares in the two scenarios. For this, we assume that the total sum of monetary output from power production remains constant in both scenarios. Then, we calculate the (scenario specific) final demand for power given the final demand of all other goods and services as in 2007. Our analysis thus should not be interpreted as a prediction. We show what two 2030 energy portfolios, including and excluding CCS, imply in an economy as observed in 2007. This way, we are certain that the observed effects are due to the difference in the power portfolio composition. More precisely, we use the power production portfolios developed in Koopmans et al. [7] for a hypothetical what-if analysis to provide insights into the order of magnitude of

[1] We use the EXIOBASE database www.exiobase.eu.

[2] See EXIOBASE [74] we use version 2.2.2 with a product by product representation.

[3] For list of countries per aggregated region see supplementary material.