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Germany's "No" to carbon capture and storage: Just a question of lacking acceptance?

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HIGHLIGHTS

- Carbon capture and storage being regarded as option to mitigate climate change loses support.
- Sustainability indicators are not the only ones stakeholders are interested in.
- Even factors distinct from sustainably indicators shows a gloomy future for CCS.
- A more intensive use of renewables will be more beneficial from an economic and social point of view.

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ABSTRACT

Carbon capture and storage (CCS) is frequently regarded as a promising approach to mitigate global warming. Yet, by and by CCS is losing political support. The key reason for that is largely seen in the lack of public acceptance for this technology. The absence of public acceptance, in turn, is in particular due to the environmental risks ascribed to CCS and the adverse effects this technology may create with respect to the development of renewable energy technologies. However, the effects of CCS are manifold and an adequate evaluation of this technology should take into account relevant aspects as comprehensively as possible. Since sustainability indicators are not the only ones stakeholders are interested in, attention also has to be paid to further indicators. By means of a multi-criteria analysis considering different scenarios, we investigate the consequences of the application of CCS in Germany that may serve as an alternative to an extension in the use of renewable energies. In doing so, we employ a set of indicators that also include factors distinct from sustainably indicators. The results show that there is a broad range of factors causing the future of CCS in the German power sector to look gloomy.

1. Introduction

Due to the entry into force of the Paris Agreement on the 4th of November 2016 the search for and the application of effective greenhouse-gas abatement policies and technologies may get a new push. In this context, already known but controversial technologies might take an active role in helping to reach ambitious targets like the 1.5 °C-target. The focus of this study is on the social, environmental and economic impacts of the application of CCS, representing such a controversial technology. We examine whether the cancellation of CCS projects could be justified or not given the different impacts.

The extension of the use of renewable energies is another option to pursue the international climate protection goals. That is why we compare a CCS deployment scenario with a scenario envisaging a high share of renewables. Within this paper, we will determine the impacts of the considered scenarios on social, environmental and economic factors.

Social, environmental and economic impacts of the use of individual technologies have been analyzed in many studies. Yet, there are research gaps in the context of related impact assessments in complex systems (see e.g., [1,2]). Varun [3], Elghali et al. [4], Dombi et al. [5], and Hofer et al. [6] for example, analyzed the impacts of selected renewable energy technologies by using up to 20 indicators. A larger number of technologies is assessed e.g. by [7–9] and [1]. In principle, an increase in the number of considered technologies does not have to result in a reduction of indicators. Roth [7], for example, analyzed 18 technologies using 75 different indicators.

Onat/Bayer [10], Chen et al. [11] and Munksgaard [12] analyzed

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energy technologies within the external-cost framework. Complex energy systems comprising different technologies have been assessed by Santoyo-Castelazo/Azapagic [2] Diakoulaki/Karangelis [13], Raugei/Leccisi [14] and Baležentis/Streimikiene [15].

Generally, the selection of the indicators is based on their relevance for the assessment of sustainable development (see e.g., [8,2]). In order to minimize both complexity and effort, the number of indicators is usually limited to 10 to 20 (see e.g., [1,2]). With respect to the dimensions of sustainability the indicators are generally ordered into the categories "economic", "environmental" and "social". Economic and environmental indicators are usually quantifiable whereas for the assessment of social aspects mainly qualitative indicators are used. Differences in units as well as differences in the characteristics of the indicators hamper their aggregation, which, however, is necessary for an overall assessment as well as for a comparison of different sets of technologies. Thus, an assessment of social aspects often remains more or less disregarded (see e.g., [16,3]).

Using a broad range of various indicators in combination with a multi-criteria approach we show how impacts of diverging energy systems can be compared. The selection of indicators is not limited to sustainability indicators. In doing so, we strive to obtain a better understanding of the various interests of stakeholders. Based on social, environmental as well as economic factors, we assess advantages and disadvantages of different pathways of an electricity supply system. Beside changes in the installed capacity we consider variations in the production as well as alterations in electricity imports and exports.

The paper is organized as follows: In Section 2 we provide a short overview of the recent developments regarding CCS. In Section 3 we describe the approach we applied for the assessment of the different scenarios. Results are presented and discussed in Section 4. Section 5 concludes.

2. Recent developments regarding CCS

Already before the Paris Agreement entered into force, CCS has been regarded – for several reasons – as a promising option to slow global warming (see e.g., [17,18]). The IEA [19] describes CCS as a key greenhouse gas abatement option in the 450-ppm scenario that is supposed to be largely consistent with meeting the international '2 °C-target'. Among the advantages of the CCS technology frequently stressed (see [20]) is that research findings for conventional fuels can still be employed and investment costs for new infrastructures – like electricity grids – required for the use of backstop technologies, e.g. solar energy technologies, can be reduced. Furthermore, it may improve security of energy supply, as coal and storage capacity for CO_2 are available on a large scale [21]. The European Parliament and the Council assume that 15% of the CO_2 reductions required in the EU in 2030 could be attained by the use of CCS [22]. De Coninck et al. [23] found no compelling reasons why CCS technologies could not be widely deployed in the EU in the future.

In Germany, an ambitious energy concept ('Energiekonzept 2050') was launched by the government in September 2010 that integrates national targets for climate protection and energy use. Germany strives for a reduction of greenhouse gases by 80–95% until 2050 (compared to the emission level in 1990), and in addition to and in support of this target, it aims to raise the share of renewable energy in total power generation to at least 80%. The main reason for the presently rapid expansion of renewable energy generation in Germany is the German Renewable Energy Sources Act (Erneuerbare Energien Gesetz) with a priority feed-in, a purchase guarantee and a fixed feed-in tariff for electricity generated by renewable energy technologies.

In Germany, the deployment of CCS therefore tends to take the role of a complement to the renewable energy deployment rather than the role of a substitute. In a joint report of several German federal ministries,[1] CCS deployment is seen as a potentially essential component of a global and national clean fossil fuel strategy [24]. In a report by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Ministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit), there is a call for further research activities on CCS technologies in order to explore their development and cost-reducing potentials and to demonstrate their feasibility in the coming years [25]. In June 2012, the House of the German Parliament (Bundesrat) approved a new CCS law allowing the sub-terrestrial storage of carbon dioxide. However, in July 2012, Peter Altmaier, at that time the acting German Federal Minister for the Environment, Nature Conservation and Nuclear Safety, pointed to the low acceptance of carbon storage by the German population. He argued that CCS could not be implemented in Germany against the will of the population. Political opposition against CCS is raised, e.g. because of its potential health, safety and environmental risks (for such risks see [26]). Some German Federal States (Bundesländer) took a hostile attitude towards CCS deployment and a special clause in the federal law on CCS allows German Federal States to ban the use of CCS in their area which some of them finally did. Therefore, it is not a big surprise that there is almost no mention of CCS in the German Climate Action Plan 2050 [27] adopted in 2016. Yet, the German government will launch a research and development program addressing industrial CO_2 recycling (carbon capture and utilization, CCU). It is only briefly stated that – if additionally necessary – CCS might also play a role in the industrial context. However, although to some extent a related technology, CCU in the industry does not address the abatement of carbon emissions stemming from back-up conventional power plants.

Not only in Germany but all over Europe most CSS-projects in the power sector have been cancelled. Table 1 shows a compilation of CCS projects in Europe that were either cancelled or put on hold. Usually a lack of acceptance has been mentioned as main reason. Financial problems as well as a lack of political support and legal constraints are usually traced back to problems of public perception.

3. Methodology

3.1. Preliminary remarks

There are several factors – also beyond the purely technical sphere – that influence the attractiveness of CCS use. According to [29,30] in the public eye CCS is generally perceived as an uncertain end-of-pipe technology that will perpetuate fossil-fuel dependence. Concerns about environmental harms from CO_2 leaks (e.g. groundwater contamination) boost the negative attitude towards CCS [31]. In many studies it is highlighted that there is in general little knowledge about CCS in the public (see e.g., [32,33]). Moreover, a lack of trust in CCS stakeholders enhances the perception of risks [34] and generally less attention is paid to opportunities and possible benefits e.g. for the local economy (see e.g., [30,34]).

Oltra et al. [35] stress that rising political opposition against CCS e.g. of non-governmental organizations and experts might induce an increase in the costs associated with CCS use. Political opposition might be raised from advocacies of alternative technologies. Environmentalists and renewable-energy lobbyists are concerned about the competition between CCS and renewable-energy technologies for R&D funds and they are concerned that CCS could raise the level of investments in large centralized power plants, which tend to reinforce present supply structures with adverse effects on energy saving efforts [36]. Thus, CCS is frequently seen in a competitive and not in a complementary way. In Germany, for example, where there have been strong public efforts to support renewable energy alternatives, the renewable energy sector has much to lose. Costs of renewable energy

[1] These ministries are the German Federal Ministry of Economics and Technology, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Federal Ministry of Education and Research.