Energy Research & Social Science 42 (2018) 155–165

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Original research article

Bioenergy with carbon capture and storage (BECCS): Global potential, investment preferences, and deployment barriers

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ARTICLE INFO

Keywords:
Bioenergy with carbon capture and storage (BECCS)
Drivers and barriers
Social acceptance
Political priority

ABSTRACT

Keeping global warming well below 2 °C entails radically transforming global energy production and use. However, one important mitigation option, the use of bioenergy with carbon capture and storage (BECCS), has so far received only limited attention as regards the sociopolitical preconditions for its deployment. Using questionnaire data from UN climate change conferences, this paper explores the influence of expertise, actor type, and origin on respondents' a) preferences for investing in BECCS, b) views of the role of BECCS as a mitigation technology, globally and domestically, and c) assessment of possible domestic barriers to BECCS deployment. Non-parametric statistical analysis reveals the low priority assigned to investments in BECCS, the anticipated high political and social constraints on deployment, and a gap between its low perceived domestic potential to contribute to mitigation and a slightly higher perceived global potential. The most important foreseen deployment constraints are sociopolitical, which in turn influence the economic feasibility of BECCS. However, these constraints (e.g. lack of policy incentives and social acceptance) are poorly captured in climate scenarios, a mismatch indicating a need for both complemented model scenarios and further research into sociopolitical preconditions for BECCS.

1. Introduction

To keep global warming well below 2 °C, current greenhouse gas (GHG) emissions must be halved by mid century and must then continue to decline [1]. This will require rapid changes in energy systems and land use practices. The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) contains about 300 scenarios considered to have a good chance of meeting the 2 °C goal. However, most AR5 scenarios are around ten years old. Recently, a new scenario framework has been developed that combines different so-called shared socioeconomic pathways (SSPs), describing global development trajectories, with representative concentration pathways (RCPs) for different climate outcomes [2]. The SSP database assembles global energy system scenarios that account for recent technological developments, such as solar and wind power, and that have integrated land use models with improved representation of biomass availability [3].

In both the AR5 and SSP scenarios, bioenergy with carbon capture and storage (BECCS) is a key technology for meeting the 2 °C goal (see Fig. 1). It has the potential to achieve negative GHG emissions and can therefore, if implemented on a large scale, compensate for a mid-century temperature overshoot by more aggressive total emission reductions or even negative emissions in the second half of the century.

However, BECCS is currently only in the development phase. Much uncertainty surrounds estimates of storage capacity, biomass availability, conflicts with biodiversity and food security goals, costs and financing opportunities, and competition for land, fertilizers, and water [4,5]. There have been efforts to capture many of these aspects in the Integrated Assessment Models (IAMs). However, sociopolitical preconditions such as political support and public opinion have so far received little attention, despite their importance for transition management [6,7]. Building on questionnaire data from three UN Framework Convention on Climate Change (UNFCCC) conferences, this paper helps fill this research gap by exploring how expertise, actor type, and origin influence respondents'

a) preferences for investing in BECCS,
b) views of the role of BECCS as a mitigation technology, globally and domestically, and
c) assessment of possible domestic barriers to BECCS deployment.

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https://doi.org/10.1016/j.erss.2018.03.019
Received 3 October 2017; Received in revised form 14 March 2018; Accepted 22 March 2018
2214-6296/

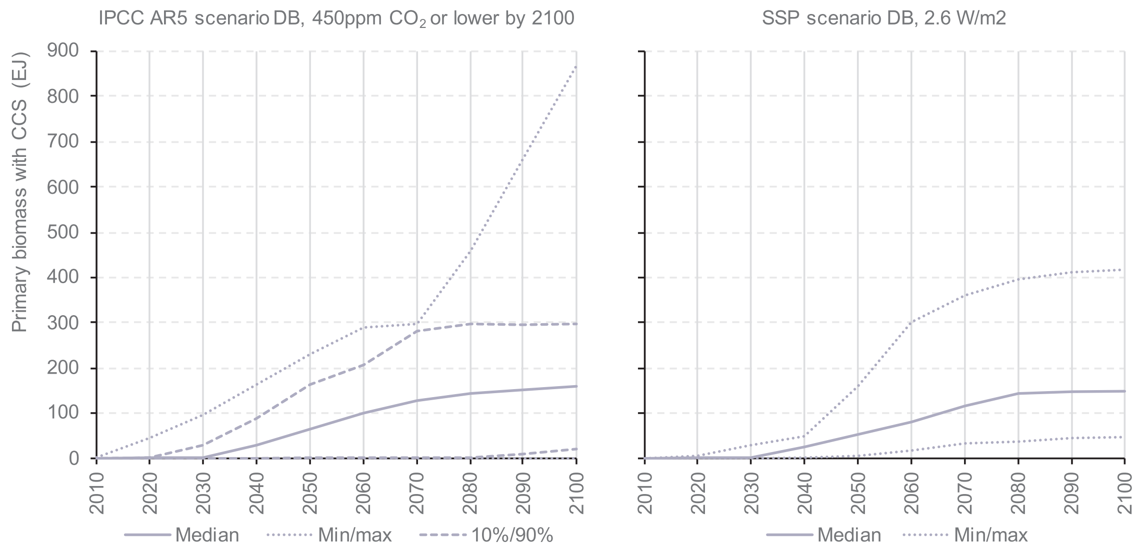

Fig. 1. Bioenergy use with CCS in primary energy supply in AR5 scenarios (left, https://tntcat.iiasa.ac.at/AR5DB) and in SSP scenarios (right, https://tntcat.iiasa.ac.at/SspDb). The figures can be compared with the total primary energy consumption in the EU (EU28) in 2014, which amounted to 68 EJ.

The results are related to scenario outcomes of current models in a forward-looking discussion of whether and how the models could be improved to produce more robust climate scenarios. The article extends a previous study by Fridahl [8] both in terms of number of responses and through introducing new survey items. Compared with the previous study, we have over twice the data on preferences for investing in BECCS, and the delegates' views of new issues are now gauged relative to global and domestic potential as well as possible deployment barriers. An expert sample has also been selected, enabling the exploration of differences between the broader sample and delegates with high knowledge of BECCS.

Section two summarizes the literature on the role of BECCS in climate scenarios, attitudes toward it, and drivers of and barriers to its deployment. Section three describes the questionnaire design, the data collection method, and the statistical analysis. Section four presents the results, which are then discussed in section five in light of the most recent scientific literature on social views of and political preferences for BECCS. Section six concludes that respondents put a low priority on investing in BECCS and that they anticipate constraints on its deployment in both the political and social domains. The results also point to a disparity between respondents' view that BECCS has little potential to contribute domestically and their slightly more positive view of its global potential. These results speak to the need for further research into the sociopolitical preconditions for BECCS deployment and for complemented model scenarios.

2. Background

Although it is a largely unproven technology, BECCS features strongly in long-term climate scenarios. When producing these scenarios, most models assume the carbon-neutral production of biomass. This assumption allows the generation of large-scale negative GHG emissions from BECCS, that is, the removal of CO_2 from the atmosphere into geological formations. Future negative emissions can potentially compensate for emissions in areas that will be difficult to mitigate completely, such as agriculture [9].

As shown in Fig. 1, BECCS is deployed in all of the new SSP scenarios compatible with an increase in radiative forcing of 2.6 W/m^2 by 2100 (i.e. likely to reach the 2 °C goal). Its deployment rapidly increases in all five model regions starting from mid century. While there have been only small changes in the AR5 and SSP median scenarios, the ranges of BECCS use have narrowed significantly in the latter, at least partially attributable to fewer scenarios.

The SSP framework considers five possible socioeconomic world developments. The sharpest increase in BECCS deployment occurs in a world characterized by delayed mitigation efforts (the so-called SSP5, see [2]). This is compatible with the literature, which asserts that delays in mitigation efforts increase the need for and importance of large-scale BECCS use late in the 21st century to compensate for the earlier temperature overshoot [4,9]. However, BECCS is deployed at significant levels in all SSPs. In fact, in the median scenario, BECCS is deployed for about 20% of the total primary energy supply in 2100. This speaks to the importance of understanding the drivers of and barriers to BECCS deployment to enable assessment of the feasibility of these scenarios.

2.1. Drivers of and barriers to BECCS deployment

Besides assuming sustainable biomass production, the scenarios informing climate policy-making also make assumptions about policy, including the assumption of a near-term globally uniform carbon price and robust international coordination. As noted by Peters [10], there "is an urgent need for scenarios based on more realistic policy assumptions" (p. 648). The literature has identified several potential drivers of and barriers to BECCS deployment that are omitted or only crudely captured in scenarios. These include the regional availability of biomass and storage capacity [9,11], political prioritization and design of policy incentives such as carbon taxes, subsidies, and price guarantees [12,11], social acceptance [13,14], and technological readiness [15].

The literature on how politicians and various non-state actors understand BECCS is very limited [16,14]. Almost all the scientific literature on negative-GHG-emission technologies comes from the natural, agricultural, or engineering sciences [7]. Analogous studies of fossil CCS report low levels of public acceptance, and demonstrate that market failure and a lack of financial incentives also act as barriers to deployment [17,18].

Dütschke et al. [13] and Fridahl [8] have, however, also demonstrated that acceptance of and preferences for BECCS differ from those for fossil CCS. The few studies focusing specifically on how BECCS is perceived conclude that both actor type and regional origin matter. For example, environmental NGOs are reportedly much more skeptical of BECCS than are governmental actors. Preferences relating to investing in BECCS also differ between world regions, with more positive views in regions with higher technical potential in terms of biomass availability and storage capacity [8]. It has also been found that public resistance to fossil CCS is stronger than to BECCS [13]. Vaughan and Gough [15], reporting on results from an expert elicitation process, concluded that