A continuing need to revisit BECCS and its potential

Though critical to many projected pathways to meet global climate targets, the challenges facing biomass energy with carbon capture and storage have yet to enter the forefront of public dialogue.

Christopher S. Galik

As work continues to finalize and then implement the Paris Agreement Rulebook, biomass energy with carbon capture and storage (BECCS) remains a flashpoint in the debate over reducing greenhouse gases (GHGs). The IPCC has suggested that BECCS could play a central role in meeting GHG reduction targets, with a vast majority of the scenarios in its Fifth Assessment Report (AR5) relying on the technology to limit global warming to less than 2 °C (ref. [1]). However, there remains a critical and continued need to consider the practical realities of BECCS and the potential disconnect between research and application[2]. Concerns have been raised about the potential to achieve the magnitudes suggested by modelling analyses, as well as the social and environmental implications of doing so[1,2]. And although more recent summaries by the IPCC[3] indicate a reduced dependence on BECCS, the technology remains a dominant contributor to strategies for achieving long-term climate stability.

The scale of BECCS estimated in economic models giving rise to the optimism is daunting. Achieving BECCS targets estimated under the RCP 2.6 pathway, for example, could require "construction and commissioning up to two large BECCS plants each week for a quarter of a century" (ref. [2], p. 6042). In the United States, projections generally suggest a high degree of deployment, with real growth beginning in 2020 and median cumulative reductions from BECCS reaching approximately 60 billion tonnes of carbon dioxide equivalent ($GtCO_2e$) for the 2010–2100 period, placing it second globally behind China[4]. To put it bluntly, "[t]his is truly massive use of a technology with little real-world experience and poorly known economics" (ref. [5], p. 707), particularly given the timeline of past deployment projections and the continued absence of commercial-scale deployment at present.

Research on, and practical experience with, conventional thermal electric biopower systems suggests that realization of the theorized potential of BECCS will be an unprecedented challenge. Looking back more than a decade, similar analysis and professional expert opinion, framed by ambitious policy goals, likewise contemplated considerable potential for conventional forms of biofuel or biopower[6]. These levels of market expansion have thus far not come to pass. In light of this history, there seem to be three primary considerations that past projections of BECCS potential have inadequately captured and that follow-on discussions have unsuccessfully highlighted.

First, although integrated assessment models (IAMs) are particularly well suited to handle the economics of different mitigation strategies and pathways, there are other considerations — such as social and governance concerns — that are less well represented. Energy infrastructure is long-lived and may face challenges that were unforeseen at the time of deployment. There are also considerations such as where to place new BECCS units, how and where to site new transportation infrastructure, and even whether new regulatory processes to oversee these shifts are necessary.

Furthermore, BECCS must be competitive with other generation sources, either in the absence of or in combination with policy support. In many IAM projections, a carbon price serves to provide the support needed to justify BECCS. Yet, even in the presence of a supportive pricing environment, deployment of BECCS depends on policy considerations that are harder to model. For example, there remain divisions over the emissions implications of both conventional bioenergy and BECCS, and the entities who will deploy or purchase BECCS-generated power must be mindful of a broader social willingness to accept the technology[7–9]. Implementation considerations such as these could inhibit BECCS deployment as a GHG mitigation strategy, even in the presence of a supportive pricing environment.

Second, the production and transportation of feedstock are important to understand in consideration of BECCS potential. Although previous analysis of feedstock availability suggests the technical potential for large-scale deployment of BECCS in the United States[10], the exercise of securing a substantial amount of biomass feedstock, likely supplied by a number of separate individuals, and transporting that feedstock to a generation facility can introduce additional uncertainty and raise the cost of doing business. Even in the presence of incentives like a carbon price, the ultimate viability of the technology may hinge on regulatory context, the availability of financing, and overcoming challenges of feedstock harvest and transport logistics[11].

Deploying bioenergy at the scale presented in recent IPCC reports is also likely to entail a variety of resource impacts[1] necessitating careful attention to resource governance and supply chain management. It is certainly possible that smaller BECCS facilities could be placed strategically across the landscape to take advantage of local feedstock, infrastructure or CO_2 injection opportunities so as to minimize landscape impact. But doing so could also counter potential economies of scale that tend to favour larger, more centralized facilities[11].

Third, there is a need to better understand the complexities of infrastructure and sequestration potential. Bringing BECCS to scale will require substantial transportation and injection infrastructure[7]. Assuming that concerns stemming from the novel nature of injection and storage technology can be overcome[12], there is still potential mismatch between where emissions are generated and where storage occurs. Baik et al.[10], for example, assess a lack of spatial correlation between biomass availability and storage reservoir suitability, estimating that spatial constraints alone could reduce the 2020 BECCS potential in the United States from 370–400 $MtCO_2e\ yr^{-1}$ to 100–110 $MtCO_2e\ yr^{-1}$.

None of the above considerations is insurmountable. Collectively, however, they present another layer of complications in the mass deployment of BECCS.

Given all this, what is to be said about the near-term prospects for BECCS? The models giving rise to the aforementioned projections of BECCS deployment are useful for assessing potential mixes of future generation technology and identification of potential trade-offs between different mitigation strategies. They are also useful for spurring conversations about the need for severe measures to meet climate mitigation objectives and about the potential viability of particular pathways. In the case of BECCS, however, those conversations have struggled to grapple with the social, economic and political barriers to deployment. These observations are not new, but the magnitude of the challenge is only slowly finding its way to the forefront of the dialogue[13].

If we assume that BECCS will play a substantial part in meeting future GHG reduction objectives, there is a need for a broader dialogue around deployment. First and foremost, there must be agreement on the net GHG benefits of BECCS and how to account for them. Second, there must be sufficient governance of the potential co-effects associated with scaling the technology, particularly elements of water consumption, biodiversity impacts and food production. Third, there must be greater awareness of the barriers to siting supportive infrastructure such as pipelines to facilitate the use of otherwise available biomass and storage resources. Notably, all three of these elements fall outside the realm of traditional IAM analyses and speak to the need to involve a wider community of scholars and practitioners. This is particularly salient given recent analysis suggesting that BECCS research involves a relatively narrow subset of the academic community[14].

Alternatively, if we consider that BECCS will be unable to overcome the challenges identified above and will instead become a "largely niche technology applied in industrial processes in a world dominated by renewables and other non-fossil energy sources" (ref. [8], p. 335), then consideration must be given to the expected size of its contribution to GHG mitigation. Future capacity need not be zero, and research suggests that BECCS may have greatest potential in contexts where there is already familiarity with its constituent elements[12]. For example, US ethanol production could yield approximately 19–30 $MtCO_2e$ of captured, transported and stored emissions annually, depending on pipeline financing arrangement[15]. But this is far below the average annual mitigation necessary to generate median-level projections of reductions attributable to BECCS in the United States, estimated to be approximately 7.5 $GtCO_2e$ between 2020 and 2050[4], or roughly 250 $MtCO_2e$ annually. To reach these levels would require not only the contributions from low-cost ethanol refineries, but also the capture of emissions from nearly all existing wood, wood-derived and biomass waste biopower capacity.

If BECCS cannot achieve the mitigation it has been tasked with, something else must take up the slack. Although such strategies may be suboptimal from a modelling perspective, it is imperative that we confront them fully, given the challenges associated with otherwise preferred solutions such as BECCS. Regardless of the path forward, the current situation speaks to the need for a broader dialogue, a dialogue that thus far has largely failed to materialize. ❐

Christopher S. Galik
School of Public and International Affairs, North Carolina State University, Raleigh, NC, USA.
e-mail: csgalik@ncsu.edu

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Carbon dioxide emissions continue to grow amidst slowly emerging climate policies

A failure to recognize the factors behind continued emissions growth could limit the world's ability to shift to a pathway consistent with 1.5 °C or 2 °C of global warming. Continued support for low-carbon technologies needs to be combined with policies directed at phasing out the use of fossil fuels.

G. P. Peters, R. M. Andrew, J. G. Canadell, P. Friedlingstein, R. B. Jackson, J. I. Korsbakken, C. Le Quéré and A. Peregon

Global fossil CO_2 emissions grew at 0.9% per year in the 1990s and accelerated to 3.0% per year in the 2000s, but have returned to a slower growth rate of 0.9% per year since 2010, with a more pronounced slowdown from 2014 to 2016. Despite modest declines in emissions in the United States and the European Union (EU) over the past decade, the growth in emissions in China, India and most developing countries has dominated global emission trends over the past 20 years. The Global Carbon Budget projection[1] suggests that global fossil CO_2 emissions will grow by 0.6% (range −0.2% to 1.5%) in 2019, with emissions projected to decline in the United States and the EU28, but projected to increase in China, India and the rest of the world (Fig. 1a).