The implications of this contribution are important. It confirms that sceptics tend to see themselves as a community with a shared identity. But this is also true for believers, a category into which many scientists fall. The findings of Bliuc *et al.* are a clear signal that the one-sided focus on sceptics needs to change. As with any conflict between two groups, efforts should be directed to prevent escalation, improve the relationships, and focus on the dynamics within groups that prevent progress.

The prevention of further escalation of conflict may be particularly important for climate scepticism: past research suggests that polarization strengthens scepticism[7]. In the case of social movements, conflict reduction is more likely if one knows the different factions that tend to exist within the movement, maintains dialogue, is open to engagement and collaboration wherever possible, and never treats different factions as though they are all the same[8].

The improvement of relations between groups partly depends on believers being able and willing to engage with climate sceptics and to jointly move towards pro-environmental action. Only a few studies (3 in this sample) have analysed whether this would be possible, and they generally are critical of current attempts to persuade sceptics. The alternatives they suggest all focus on new ways of communicating with sceptics: by focusing on future scenarios, including sceptics in collective deliberation and social movements, or by collaborating with them toward joint goals for society[9]. These all echo well-known approaches that try to decrease conflict between groups by collaborating on superordinate goals.

A final way of reducing intergroup conflict reflects on the dynamics within groups that prevent progress. The reason people feel they belong to movements is partly because the image of two irreconcilable camps is promoted both by the media but also on each side of this divide. In an atmosphere of conflict, people tend to talk badly about the outgroup as a way of expressing solidarity with their own side. The mantra among believers, for example, is that climate change contrarians ignore a unanimous community of scientists. But research suggests that both images are wrong. There is never complete agreement even among scientists, so depicting climate scientists as 100% unanimous on the causes of climate change is counterproductive[10]. Similarly, sceptics are not one block united against science: there are many different reasons for scepticism, doubt or uncertainty about climate change[11]. The results of Bliuc *et al.* show that future research and theorizing can make a major advance by studying how this head-to-head clash between social movements (whether real or imagined) can be avoided and resolved: understanding group dynamics will help to change beliefs about climate change. ❐

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POWER SYSTEMS

Carbon negative at the regional level

Modelling of the power system on the west coast of North America shows that including bioenergy with carbon capture and sequestration technologies could enable the region to be carbon negative by 2050.

Nico Bauer

Investigating decarbonization pathways is a key component of informing policymakers and society about the potential for mitigating climate change. Several model-based studies have explored decarbonization scenarios for national, regional and global power sectors[1,2]. However, although the need to include negative CO_2 emissions in such analyses has been recognized in global energy sector studies, few national or regional models have included negative-emission technologies[3,4]. Writing in *Nature Climate Change*, Daniel Sanchez and colleagues present findings that are of interest far beyond the boundaries of the power sector in the west coast region of North America that they studied[5]. The authors map out the potential for the area's CO_2 emissions to be reduced by 2050, including what would be required to achieve net negative levels.

Sanchez and colleagues used an extension of the SWITCH power-sector model[6], assessing with a high level of spatial detail the region's bioenergy supply, which comprises mostly forestry and agricultural residues, and considering various technologies for electricity generation, including bioenergy with carbon capture and storage (BECCS). The authors present implications for the regional power sector and derive marginal abatement costs associated with deep emission reductions and even negative emissions (to –145%) in 2050 compared with 2020 levels.

BECCS is a highly debated technology option[7] that offers, like afforestation, the possibility of removing CO_2 from the atmosphere. The IPCC's Working Group III concluded that the development of CO_2 removal technologies and their large-scale deployment is crucial to any scenario under which there is a high likelihood of keeping global warming below 2 °C (ref. 8). This conclusion was derived from a large body of scientific literature that applied a set of global integrated assessment models (IAMs) projecting alternative futures until 2100[9], most of which focussed on BECCS as the key option for CO_2 removal. The availability of BECCS and a high supply of lignocellulosic material for bioenergy are projected to be critical requirements for achieving the 2 °C target and containing the associated costs[8,9].

The IPCC's Working Group III summarized that IAMs tend to agree that the global electricity sector could be largely decarbonized in 2050 at a marginal abatement cost of about US$110–165 per ton of CO_2, with a significant share of the decarbonization deriving from CCS, and in particular BECCS[10]. This makes the electricity sector vital to achieving reductions in total CO_2 emissions, as it can be decarbonized more easily and more rapidly than other sectors, such as transportation. Negative emissions from the power sector can also offset residual emissions from the transportation sector, as well as past emissions, thus allowing some of the burden of emission reductions to be shifted to the future. For these reasons, CO_2 removal technologies like BECCS are valuable for society[8,11].

The strength of IAMs lies in their global coverage and the integration of the energy sector with the climate system and the economy. However, these models are criticized for being too aggregate and too coarse. Aggregation basically means averaging, so some low-hanging fruits might be missed and — more importantly in the context of deep decarbonization scenarios — bottlenecks, barriers and issues could be ignored. This might bias the results towards the optimistic side and hide some of the ancillary costs and risks of climate policy options. Although IAMs are excellent tools to assess interdependency between sectors and systems, this form of analysis relies on various assumptions rooted in spatial, temporal and technological detail.

This is where the study by Sanchez and colleagues comes in. First, the authors find that, for the North American west coast region, the BECCS option becomes economically viable at US$76 per tCO_2, and emission reductions of 86% or 105% can be achieved by 2050 at marginal abatement costs at about US$120 and US$165 per tCO_2, respectively. This result confirms the IPCC's conclusion based on global IAMs. Second, they show that implementing BECCS in the electricity sector offsets emissions from gas-fired power plants and residual emissions from coal-fuelled power plants equipped with CCS; if bioenergy and CCS are not available, higher shares of wind, solar and hydro power sources are needed to compensate for the missing power generation from bioenergy and also coal and gas. Third, they show that the −145% emission target is achievable, but that meeting it would imply marginal abatement costs above US$1,000 per tCO_2 in 2050. Similarly high costs are also incurred for emissions reductions of only 86% if BECCS is not available. Finally, the study highlights that, although the share of BECCS in the modelled electricity generation mix is small (less than 10%), the negative emissions this technology generates make low emission targets feasible. Furthermore, BECCS also helps to balance fluctuations in power generation from wind and solar sources.

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Agricultural biomass residues make the west coast of North America a prime candidate region for using bioenergy use with carbon capture and storage (BECCS) to reduce CO_2 emissions.

Sanchez and colleagues' regional results mostly confirm the IPCC's global assessment and IAM findings that the offsets produced by BECCS are more valuable to the power system than the electricity the technology supplies. The study is a blueprint for analysis of power sector decarbonization pathways for other regions. Moreover, it provides a wealth of information for policymakers and power-sector planners on decarbonization pathways for the west coast of North America. Future studies should also aim at identifying bottlenecks and barriers that could limit the potential to implement BECCS-based strategies. For example, there may be difficulties in scaling up BECCS capacities[12], and some technologies are still under development, such as gasification processes for different bioenergy feedstocks. These constraints will need to be taken into account in future studies of the deployment and diffusion of BECCS, both in different regions and worldwide. ❐

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