ROGER PIELKE JR.

Opening Up the Climate Policy Envelope

Fudged assumptions about the future are hampering efforts to deal with climate change in the present. It's time to get real.

Policy action is required to mitigate and adapt to human-caused climate change, but current efforts to develop a global climate policy cannot fly. What the world's leaders have been able to agree on will not prevent the steady increase in greenhouse gases in the atmosphere and the risks of climate disruption that will result.

For an aircraft to fly it must operate within a flight envelope, the combination of conditions such as airspeed, altitude, and flight angle necessary for successful operation. For a specific approach to climate action to succeed, it must operate within a policy envelope, the combination of policy design and political, economic, technological, and other conditions necessary for the approach to be effective.

If aircraft designers sought to improve the performance of a poorly designed aircraft not by improving its design, but by rejiggering their claims about aerodynamics, or airfoil design, or jet fuel combustion thermodynamics, to match the aircraft performance they desire, it is obvious that the aircraft would still perform badly. In the case of climate change, policy-makers and climate experts are doing something similar. In the face of ongoing failure to reduce global greenhouse gas emissions, they are rejiggering the way they define the climate change challenge as if that will somehow allow policies that have been failing for over 25 years to become successful.

Understanding the unexplored dimensions of a policy envelope can be particularly important in situations of policy failure or gridlock. Sometimes new options are needed in order to break a stalemate, enable political compromise, or create new technological possibilities. The exploration of options can also give confidence that the policies being implemented do not have better alternatives. Thus, an important role for policy analysts, especially in the context of wicked or intractable problems, is to understand the ever-changing dimensions of the policy envelope in a particular context to assess what might be possible in order for progress to be made, perhaps even expanding the scope of available actions.

The failure of global climate policies to date suggests that new policy options should be explored—that we may need a significantly expanded policy envelope to begin to make satisfactory progress. But rather than exploring such options, we have instead been protecting the current policy envelope from critical scrutiny. One mechanism of such protection is via scenarios and assumptions that underlie the authoritative policy assessments of the Intergovernmental Panel on Climate Change (IPCC).

Inside the envelope

The dynamics at play are complex and somewhat circular. In the 1980s and '90s scientists and policy-makers concluded that accumulating carbon dioxide in the atmosphere would be best addressed via an international treaty that focused on incremental reductions in emissions, based on negotiations among countries. This approach culminated in the 1992 United Nations Framework Convention on Climate Change (UNFCCC), followed by its various incremental offspring, including the Kyoto Protocol of 1997 and the celebrated Paris Agreement of 2015. The social scientist Steve Rayner of Oxford University argues that this approach incorporated "borrowings from other international governance regimes addressing stratospheric ozone and nuclear weapons as well as the USA's experience with SO2 [sulfur dioxide] emissions trading." The focus was thus on an international process with successive and incremental commitments to emissions reductions made by participating parties, supported by mechanisms of measurement and verification.

An important role of climate research in this regime was to provide ever more certain justifications for action and key guidance on the details of implementation. The IPCC thus focused on providing technical support for the UNFCCC. A key element of this support has been the development of scenarios of the future that show how the world might look decades hence with and without climate policies under the UNFCCC, so that policy-makers might understand costs and benefits of proposed actions. These scenarios thus support the formulation and implementation of climate policies within a policy envelope that was established by and has been pursued under the UNFCCC.

The restricted policy envelope that results from the scenarios of the IPCC—typically formalized in the form of so-called integrated assessment models—is the result of two reinforcing sets of assumptions. One is that the costs of inaction will be high due to projected large changes in climate resulting from a massive increase in future emissions and resulting negative impacts on societies. The second is that necessary incremental actions to reduce and ultimately eliminate emissions will be technologically feasible at low cost, or even at no net cost at all—that such actions are economic and political no-brainers.

Both sets of assumptions may well prove to be correct. But what if the costs of inaction are not so high or the costs of incremental action are not so low? What if the current approach to climate policy reinforces a partisan divide and fuels its own opposition? What if there are other ways to address the challenge? What if our view has focused on a policy regime that cannot succeed? What if we need to think differently in order to succeed? How many more decades of failing to make real progress will be necessary before asking such questions is not only politically acceptable but unavoidable? What if it is then too late?

At the center of the current approach is a target and a timetable. The target is to stabilize concentrations of carbon dioxide in the atmosphere at a low level. In the past this level was commonly expressed as 450 parts per million carbon dioxide equivalents, and more recently has been expressed as a temperature target such as 2 degrees Celsius (2°C). Under the Kyoto Protocol, the timetables for emissions reduction were specified quantitatively for certain participating counties, and when this did not work the Paris Agreement allowed countries to specify targets for themselves. Neither approach has proved effective at securing emissions reductions, much less making progress toward a stabilization or temperature target.

In 2012 the physicist Robert H. Socolow argued in the *Vanderbilt Law Review* that the 2°C target was not so much a policy goal but rather a political motivation, reflecting "a mindset that is common to the entire exercise: to create maximum pressure for action. The action most on the minds of the proponents of 'two degrees' is deep transformation of lifestyles and the industrial structure of the OECD [Organization for Economic Co-operation and Development]. Implications for developing country industrialization receive little attention." Under the Kyoto Protocol, developing countries were not expected to reduce emissions, nor are they under the Paris Agreement, at least not until far into the future. Vast parts of the world have yet to achieve the full bounty of energy services available in OECD countries, and climate politics has tiptoed around this inequity for decades. Not surprisingly, emissions have increased dramatically in parts of the world experiencing rapid economic growth.

If climate policy can't be made to work in the real world thus far, then at least it can be made to work in the scenarios and models of the future that underpin the debate. It is Policy Analysis 101 to consider the consequences of alternative policy interventions, and economic and other types of models can often help us to productively understand these consequences and associated uncertainties. But in addition to supporting insight, models and scenarios can obstruct understanding and discourage critical thinking.

Discussion of climate policy options has long depended on the generation of scenarios of the future that include a wide range of assumptions, such as growth in population and wealth and prospects for technological innovation in energy production and consumption. These scenarios serve multiple purposes. For instance, they are used to generate projections of future greenhouse gas emissions, which can then be used as a key input for physical climate models, which in turn project future changes in climate. These projections can tell us something about the consequences of alternative interventions, and of inaction as well. Scenarios are also used as the basis for projecting the scale and scope of possible policy actions, including the projected costs and benefits of different approaches to climate mitigation.

Typically, two categories of scenarios are developed. *Baseline scenarios* are used to describe a future in which society continues to change, but no intentional action is taken on climate mitigation. Policy scenarios are used to describe a departure from the baselines, to describe a future in which action is taken on climate mitigation. Both baseline and policy scenarios have many assumptions about the future built into them, and both have profound implications for our view of the climate policy envelope, and by extension for which policies are considered as worth pursuing and which are not.

Scenarios are essential because to move into the future intentionally we need some expectation of how actions and outcomes may be related. But scenarios may become captured by assumptions and beliefs about how the world does or should work, and thus can limit our vision of possible futures, and make us vulnerable to surprises.

Assume a light saber

An obvious example of myopia induced by climate policy scenarios can be found today in the role played in scenarios of bioenergy with carbon capture and storage, called BECCS, a technology that combines biomass energy production with the storage of carbon dioxide. BECCS allows for "negative emissions"—the removal of carbon dioxide from the atmosphere through the large-scale growing of plants, which are then combusted to create energy, with the carbon dioxide emissions from the combustion then captured and stored, presumably in deep geological formations. BECCS technologies thus serve two important functions in scenarios of the future: they serve as a source of carbon-free energy supply needed to replace fossil fuels, and as a sink for carbon dioxide in the atmosphere. Large-scale BECCS technologies do not yet exist.

Negative emissions technologies are a relatively new addition to climate policy discussions, appearing in the academic literature in the past 20 years and then making their way into integrated assessment models about a decade ago. A 2005 IPCC report on carbon capture and storage mentioned "negative emissions" in passing and cautiously suggested it as a "possibility … [that] may provide an opportunity to reduce CO2 [carbon dioxide] concentration in the atmosphere if this option is available at a sufficiently large scale." The report noted that BECCS "is a new concept that has received little analysis in technical literature and policy discussions to date." Not surprisingly, at that time BECCS was not a technology incorporated in IPCC scenarios and models of the future.

In 2007 the IPCC Fourth Assessment Report noted that "current integrated assessment BECCS scenarios are based on a limited and uncertain understanding of the technology. In general, further research is necessary to characterize biomass' long-term mitigation potential." Yet by 2013, such caution had been left far behind, and negative emissions were central to nearly all scenarios of the IPCC Fifth Assessment Report that are compatible with a 2°C target. In less than a decade negative emissions went from an afterthought to being absolutely essential to international climate policy. No government had actually debated the merits of BECCS, there were no citizen consultations, and very little money was being devoted to research, development, or deployment of negative emissions technologies. Yet there it was at the center of international climate policy.

In a 2013 paper, Massimo Tavoni and Socolow observed that negative emissions first appeared in the scenarios of the IPCC Fourth Assessment Report associated with new demands for increasingly strict emissions targets, such as 2°C . "Subsequently, many models have incorporated [carbon dioxide removal], thereby increasing the options for achieving stringent climate targets," they noted. "Thus, paradoxically, despite little progress in international climate policy and increasing emissions, long-term climate stabilization through the lens of IAM [integrated assessment models] appears easier and less expensive." An option was created, not in the real world, but in models that sustain the current policy envelope.

The result was to make business-as-usual climate policy under the UNFCCC appear to be on track. The paradoxical result, as Tavoni and Richard S. J. Tol noted in 2010, was that demands for more stringent climate targets were accompanied by greater apparent policy feasibility at lower cost. "In order to be able to satisfy this new policy demand," they said, "the models that have analyzed the more ambitious policies have been pushed towards implementing more optimistic assumptions about the range and availability of their mitigation portfolio, which has the effect of lowering the costs of climate policies." Because the proposed technologies were speculative and at best well off into the future, estimates of the costs and feasibility of their implementation could be tailored to the needs of sustaining the policy regime. Peter A. Turner and colleagues have observed that whereas "BECCS appears to be cost-effective in stylized models, its feasibility and cost at scale are not well known." Of course not. If nothing else, full implementation of BECCS "at scale" would require the use of a global land area one and a half times the size of India (land that will therefore not be available for agriculture or other uses). In the absence of any justifiable method for predicting actual costs, why not just assume that BECCS will be affordable?

BECCS technologies are fundamental to the new family of IPCC scenarios designed to take climate policy discussion into the 2020s. Sabine Fuss and colleagues observe that some extreme scenarios foresee BECCS accounting for more than 1,000 gigatons of carbon dioxide over the twenty-first century, with a median removal across the new generation of IPCC scenarios of 12 gigatons per year. For comparison, in 2017 carbon dioxide emissions from fossil fuels emissions worldwide totaled about 37 gigatons. Glen Peters, of the Center for International Climate Research in Oslo, Norway, notes that in IPCC's forthcoming Sixth Assessment Report, BECCS plays a central role and can be found in 78 of 80 of its new family of policy scenarios.

The Paris Agreement on climate change does not mention BECCS technologies, yet achievement of its goal to hold temperature increases to below 2°C is fully dependent upon them in the IPCC's scenarios of policy success. Wilfried Rickels and colleagues concluded in 2017, "Achieving the 2°C and even more the 1.5°C goal is unrealistic without intentional atmospheric carbon dioxide removal." Take away the speculative technology embedded across scenarios and models and the entire policy architecture of the Paris Agreement and its parent, the UNFCCC, falls to pieces, just as would an aircraft fatally outside its flight envelope. Oliver Geden, of the German Institute for International and Security Affairs, argues that scenarios thus hide policy failure: "By establishing the idea of negative emissions, climate researchers have helped, unintentionally, to mask the lack of effective political mitigation action."

Carbon dioxide removal at massive scale is science fiction—like a light saber, incredible but not real. Yet BECCS plays a very real role in today's climate policy arena, by helping to maintain the climate policy envelope and save us from having to do the enormously difficult and uncomfortable work of thinking how we might go about addressing accumulating carbon dioxide in the atmosphere differently than we have since the 1980s and '90s. Yet BECCS is not the only important assumption in scenarios that serves to limit the scope of the climate policy envelope.

Assume you're running downhill

Another key assumption found in scenarios and models used by the IPCC has to do with the rates at which the global economy will become less energy intensive (for example, through gains in energy efficiency, and the dematerialization and increasing productivity of economic activity) and how fast global energy production will become less carbon intensive. Such decarbonization (technically, the ratio of carbon dioxide emissions to global gross domestic product) occurs in the absence of climate mitigation policies, and is thus termed spontaneous decarbonization. It is an important feature of baseline IPCC integrated assessment scenarios for the future.

Policies to mitigate climate change seek to accelerate the rate of decarbonization of the global economy, a job made easier to the extent that the world is also decarbonizing due to normal processes of technological change. Small changes in assumptions of future rates of such spontaneous decarbonization can thus have an enormous impact on the role for and costs of future climate mitigation policies.

Consequently, assumptions of spontaneous decarbonization are essential to understanding the magnitude of the challenge of stabilizing concentrations of carbon dioxide in the atmosphere. For instance, a 2017 report by the PwC corporation, based in the United Kingdom, estimated that the global economy will have to decarbonize at a rate of 6.4% per year through the end of the century if the 2°C target of the Paris Agreement is to be achieved—where 6.4% is the sum total of spontaneous and intentional decarbonization. From 2000 to 2016 the world decarbonized at a rate of 1.4% per year. That leaves a decarbonization gap of about 5% per year between recent rates of decarbonization and that demanded by a 2°C target. Simple mathematics means that every year the world fails to achieve the needed rate of decarbonization, that gap increases.

The size of the 5% decarbonization gap can be instantaneously much reduced in the future if for the remainder of the century we assume that instead of the 1.4% rate of decarbonization observed so far this century, the world will spontaneously decarbonize at, say, 2.4% or 3.4% or even more per year, in coming decades. For instance, if we assume future spontaneous decarbonization of 3.4%, then the decarbonization gap to be addressed by new climate policies would be just 3% per year. Of course, such optimistic assumptions might not be correct, as the future is uncertain. The point here is not that such assumptions of the future are necessarily wrong or not justifiable, but rather that they represent a subset of what might be possible. We can modulate how much policy ambition might be needed to stabilize carbon dioxide in the atmosphere simply by changing our assumptions for future spontaneous decarbonization.

Tom Wigley, Christopher Green, and I observed a decade ago that the vast majority of projected emissions reductions found in the IPCC scenarios produced in 2000 came from assumptions of spontaneous decarbonization, and not from climate policies. Many such assumptions were far more aggressive than what had been observed in the recent past. This result was consistent across all the IPCC scenarios. The reliance on spontaneous decarbonization to carry a large proportion of future emissions reductions was repeated in the next generation of IPCC scenarios, which were the basis of IPCC's Fifth Annual Assessment, and is once again found in the newest scenarios to inform the Sixth Assessment.

Before there was BECCS, assumptions of spontaneous decarbonization did a lot of the work of reducing future emissions in climate scenarios and models. And as with BECCS, assumed rates of spontaneous decarbonization necessary to achieve desired results had yet to occur in the real world but were assumed to be reasonable in the future. Today with scenarios and models having both BECCS and spontaneous decarbonization in them, progress toward reducing emissions seems to be inevitable and easy—in imaginary future worlds.

Moreover, spontaneous decarbonization and BECCS serve a sort of Goldilocks role in climate policy. More aggressive assumptions about each of them can make the emissions problem largely or entirely go away on its own. Less aggressive assumptions would indicate the impotence of current approaches and suggest potentially higher costs in the future to mitigate emissions. And so, magically, the IPCC scenarios assume just the right amount of each in order to preserve the plausibility of the climate policy envelope that has characterized the issue for almost 30 years.

In 2007, Ian Sue Wing and Richard S. Eckhaus called such assumptions a "fudge factor" that "allows the results of climate-economy simulations to be tuned according to the analyst's sense of plausibility." Of course, some assumptions found in scenarios will likely prove to have correctly anticipated the twenty-first century. But shaping policy to address a limited set of futures represents a bet on those futures, and against other possibilities. The risk in such a bet is that the future plays out differently than assumed and the policies designed for that narrow set of futures prove not to address the problems that motivate the policies to begin with.

Predicting a different past

A third example of a key assumption used to reinforce the boundaries of the business-as-usual climate policy envelope has been the heavy reliance on a particular emission scenario, called RCP (Representative Concentration Pathway) 8.5, in climate impact studies. The RCP 8.5 scenario is based on an assumption of the dramatic expansion of coal energy around the world over the twenty-first century that results in extremely high carbon dioxide emissions, in fact the most emissions of any scenario used by the IPCC in its Fifth Assessment Report. Despite its outlier status, RCP 8.5 is the most commonly used scenario in climate impact studies, appearing in thousands of academic papers. Climate impact studies generally use physical climate models to project how the climate system might change in the future, with particular attention to such phenomena as heat waves, floods, drought, and hurricanes. The use of an extreme emissions scenario yields larger and more significant changes to climate in the future. The characterization of an extreme scenario as "business as usual" implies that it is a baseline scenario, a vision of what is likely to happen in the absence of climate policies.

However, RCP 8.5 is not a business-as-usual scenario and has been criticized for its unrealism. Justin Ritchie and Hadi Dowlatabadi concluded in 2017 that "evidence indicates that RCP 8.5 does not provide a physically consistent worst case BAU [business-as-usual] trajectory that warrants continued emphasis in scientific research, it does not provide a useful benchmark in policy studies." In early 2017 the team of researchers responsible for producing the scenarios that will underpin IPCC's Sixth Assessment observed that emissions consistent with RCP 8.5 "can only emerge under a relatively narrow range of circumstances."

Yet RCP 8.5 remains a scenario favored in most climate impacts studies published in the academic literature. One reason for this is obvious: because the scenario generates very high carbon dioxide emissions, the associated climate impacts projected in climate models can also be very large, and thus lend continued urgency to calls for emissions reductions, and supporting economic models that show very high costs of future climate change impacts.

RCP 8.5 can also be deployed to demonstrate large impacts of climate change today. For instance, following the disastrous flooding associated with Hurricane Harvey in Houston, Kerry Emanuel, a researcher at the Massachusetts Institute of Technology, published a paper in the *Proceedings of the National Academy of Sciences* concluding that floods such as Harvey's had become six times more likely in the past 25 years due to greenhouse gas emissions. The paper's conclusion was widely covered in the media.

To generate these large changes over the past 25 years, Emanuel used a unique methodology that relied on no actual data from the past. Using climate model simulations based only on the RCP 8.5 emissions scenario, the paper projected how climate impacts associated with hurricane-related flooding might change to 2100. The study then calculated how much change had occurred over the recent past by assuming that the changes that have occurred to date fall on the same trend line that RCP 8.5 projects for the future.

Why describe the impacts of greenhouse gases on hurricane-related flooding that have already happened by using a particular scenario for 2100, when those impacts can be empirically described by enormous amounts of actual data, from which empirically validated trends can be determined? Consider that if Emanuel's study had used a scenario for 2100 that had emissions stabilized at a low level, then the change in the risk of flooding like that of Hurricane Harvey over the past several decades in the study would have been minimal or none at all. The choice of scenario for 2100 thus changes how our recent history is viewed. In fact, empirical research on long-term trends of hurricane-related heavy rainfall and flooding in the United States has found no trends.

Dramatic findings of climate disasters resulting from greenhouse gas emissions serve an important function in helping to maintain the boundaries of the business-as-usual climate policy envelope. Large projected impacts typically imply large future costs of changes in climate under baseline scenarios. In a benefit-cost exercise, the avoidance of large projected costs is a benefit of climate mitigation policies. Carbon dioxide removal, spontaneous decarbonization, and large future impacts under RCP 8.5 thus all work in the same direction in cost-benefit analyses, but on different sides of the equation. Indeed, the larger the projected costs of inaction under RCP 8.5, the larger the allowable set of scenarios under which climate mitigation policies can provide a positive benefit-cost ratio (above 1.0).

Under scenarios that generate impressive benefit-cost ratios across the twenty-first century, an unwillingness to support climate policies with high short-term costs but higher long-term benefits looks economically irrational at best, a disastrous manifestation of “climate denialism” at worst. Using RCP 8.5 to project future climate impacts can help us understand a potential worst-case scenario, but using it as a generic business-as-usual scenario thus contributes to the toxic politics of climate policy. It feeds into suspicions that scientists are putting their thumb on the scale of climate models in order to generate projections that emphasize the more dire possible futures of climate change, however unlikely these may be.

The three key assumptions discussed above—negative emissions, spontaneous decarbonization, and reliance on RCP 8.5 as climate policy business as usual—are far from the only ones that can be used to modulate or restrict the boundaries of the climate policy envelope. For example, as I’ve explained elsewhere, one can help meet emissions targets in emissions scenarios simply by assuming that hundreds of millions of people in developing countries will fail to achieve significant levels of energy access.

But we cannot assume away the failure of climate policy today. Climate policy business as usual has been accompanied by an increase in global fossil fuel consumption of almost 60% since the 1992 Rio Earth Summit that gave rise to the United Nations Framework Convention on Climate Change, as well as to a corresponding increase in carbon dioxide emissions. What the world is doing is not working.

Climate denial of another kind

Some observers have pointed out the obvious. For instance, in 2012 Robert Socolow warned, “No one appears to be preparing for a time—possibly quite soon—when a consensus develops that a peaking of emissions in the 2020s will not occur and that therefore (at least in this meaning) ‘two degrees’ will not be attained.” Yet rather than open up discussion of climate policy to new possibilities, the main response to such observations has been climate denialism of another sort, manifested in the Paris Agreement’s call for a more stringent target (1.5°C), made seemingly feasible by the incorporation of assumptions about the future that are at best wildly optimistic.

We need to break free of such assumptions in order to recognize that the current policy envelope does not contain the pathways to meaningful progress, but rather is an obstacle to discovering such pathways.

If the IPCC is unable or unwilling to consider a more expansive climate policy envelope, then others in leadership positions might explicitly take on this challenge. It won’t be easy. Business-as-usual climate policy has a large and powerful political, economic, and social constituency. Repeated policy failures, most obviously the Kyoto Protocol, have been insufficient to motivate a change in thinking or direction. Although the Paris Agreement helpfully abandoned pretentions of a top-down fix, it did little to change thinking about how its targets were to be achieved. And whereas it’s easy to blame the intransigence of the United States for lack of progress, such a tack is just another way to try to protect business-as-usual policy, for the fact is that the rest of the world isn’t making progress either.

The work on the IPCC’s Sixth Assessment Report looks to be similar in form and function to that of past reports, designed to support the UNFCCC but certainly not to open up new possibilities that might require different institutional arrangements.

An expansion of the boundaries of a climate policy envelope is different from a search for specific solutions to a narrowly defined problem. Rather, it represents a search for circumstances under which alternative, effective policy interventions might be possible. In the best cases such an exploration can result in practical options previously not considered, and in new coalitions of actors coming together in new political arrangements to seek progress.

What might an exploration of a more expansive climate policy envelope look like? Below are some questions that push toward an expanded set of options, but once we set our collective attention to the task, no doubt a dramatic expansion of ideas and possibilities would multiply quickly.

- What do climate policy options look like if BECCS is not assumed in scenarios and models?
- What happens if we abandon the 2°C temperature target? Oliver Geden observes: “Worldwide, there has been almost no questioning of the parties’ intention to hold the temperature increase to below 2 or 1.5°C.” What alternative long- or short-term targets might be used to track climate policy progress?
- One possibility might include a commitment to the expansion of carbon-free energy in national energy mixes, as achieving zero emissions will require that almost all energy consumption come from sources that are carbon neutral. The world currently is at less than 15% carbon-free energy consumption. What might a technology-focused climate policy architecture focused on targets and timetables for the adoption of carbon-free energy sources look like (rather than emissions or temperature targets)?
- Succeeding in the stabilization of carbon dioxide at low levels in the atmosphere will require a massive

reduction in the use of fossil fuels. There has been essentially no serious international policy focus on how this might actually be done. Consider that the world consumes more than 11,000 million metric tons of oil equivalent (MTOE) of fossil fuels each year, according to the multinational energy corporation BP. If this number is to approach zero, then the world would need to retire and replace about 1 MTOE each day until 2050. That is the equivalent of more than a nuclear power plant's worth of carbon-free energy, every day. How might the world decommission such a magnitude of fossil fuel energy? The UNFCCC policy envelope has been an exercise in avoiding this question. What would it mean to get serious about answering it?

- The massive scaling of technologies that do not yet exist or do not exist at scale would require a commitment to dramatically enhanced national and international innovation policies. What policy options would support innovation at the scale needed to transform the global energy system? Are there innovation investments or practices that would be amenable to targets and timetables? Above all, what magnitude of investments is likely to be necessary for a massive scale-up in carbon-free technologies?
- Climate policy discussions have tended to emphasize worst case scenarios of the future. What might climate policy look like if scenarios expected to represent more likely futures are placed at the center of climate policy discussions? How might costs and benefits look under such scenarios? What new policy options might become politically plausible with changes in predicted costs and benefits focused on central tendencies and not extremes?
- What might climate policy look like if costs and benefits of proposed policies are not calculated over decades and longer (e.g., under assumptions of future spontaneous decarbonization), but instead are examined from a perspective of one or several years, so as to be more consistent with political calendars?

These a just a very few possibilities for the sorts of questions that might be asked that would lead to an expanded climate policy envelope. Additional challenges and opportunities for an expanded policy envelope could come from consideration of factors such as non-carbon climate forcings, land use change, adaptation, global energy access, and expanded consumption, or the many other dimensions of energy and climate policies, any of which might add fruitful new options to the policy envelope.

One possible outcome of such an exercise could be that we will quickly learn that we don't currently know how to fully address the challenge of stabilizing concentrations of carbon dioxide in the atmosphere at a low level. There is nothing wrong with acknowledging ignorance, and doing so can be an important motivation for a search for new, more effective approaches that emphasize a variety of first possible steps toward meeting a difficult challenge, rather than continuing to focus, as we have been doing, on a narrow pathway toward its completion. As a group of my colleagues wrote in "The Hartwell Paper," in the aftermath of the disastrous 2009 Copenhagen climate conference, "for progress to occur on climate policy, we must reframe the issue in a fundamental way."

We don't know much about the scope of the climate policy envelope because we have done little to explore its dimensions since it was first locked in more than 25 years ago. Climate policy business as usual means that we go exactly where we have been headed, repeating the same behavior, and modifying our assumptions to accommodate our continuing failure to make progress.

The uncomfortable alternative is to open up debate beyond the constraints imposed by scenarios and models that have reinforced boundaries on the discussion of policy options, and begin to explore a future that is at once more daunting and more rich with opportunities for making progress.

Roger Pielke Jr. *(pielke@colorado.edu) is a professor in the Environmental Studies Program at the University of Colorado, Boulder.*

Recommended reading

Gwyn Prins, Isabel Galiana, Christopher Green, Reiner Grundmann, Atte Korhola, Frank Laird, Ted Nordhaus, Roger Pielke, Jr., Steve Rayner, Daniel Sarewitz, Michael Shellenberger, Nico Stehr, and Hiroyuki Tezuka, "The Hartwell Paper: A New Direction for Climate Policy After the Crash of 2009," University of Oxford and the London School of Economics (May 2010).

Peters GP, and Oliver Geden, "Catalysing a Political Shift from Low to Negative Carbon," Nature Climate Change 7, no. 9 (2017): 619.

Steve Rayner, "How to Eat an Elephant: A Bottom-Up Approach to Climate Policy," Climate Policy 10, no. 6 (2010): 615-621.

S. Fuss, J. G. Canadell, G. P. Peters, M. Tavoni, R. M. Andrew, P. Ciais, R. B. Jackson, C. D. Jones, F. Kraxner, N. Nakicenovic, and C. Le Quéré, "Betting on Negative Emissions," Nature Climate Change 4, no. 10 (2014): 850.

Roger Pielke, Jr., The Climate Fix: What Scientists and Politicians Won't Tell You about Global Warming (New York, NY: Basic Books, 2010).

Roger Pielke, Jr., T. Wigley, and Christopher Green, "Dangerous Assumptions," Nature 452, no. 7187 (2008):531.

J. Ritchie and H. Dowlatabadi, "Why Do Climate Change Scenarios Return to Coal?" Energy 140 (2017): 1276-1291.