BROOKINGS

Highlights from the Cross-Brookings Initiative on Energy and Climate

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INDEPENDENCE

Contents

About the Cross-Brookings Initiative on Energy and Climate iii

Cross-Brookings Initiative on Energy and Climate Scholars iv

Undiplomatic action – A practical guide to the new politics and geopolitics of climate change 1
David G. Victor and Bruce D. Jones

The danger in deregulation 23
Samantha Gross

China's coal consumption has peaked 25
Qi Ye and Jiaqi Lu

Nobody knew border carbon adjustments could be so complicated 29
Warwick J. McKibbin, Adele Morris, Peter J. Wilcoxen and Weifeng Liu

Is the United States the new Saudi Arabia? 31
Samantha Gross

Patenting invention – Clean energy innovation trends and priorities for the Trump administration and Congress 35
Devashree Saha and Mark Muro

About the Cross-Brookings Initiative on Energy and Climate

Brookings's Pivotal Role

The Brookings Institution is uniquely positioned to tackle the many challenges raised by the world's transition to a lower carbon energy system. Led by Co-Chairs Bruce Jones, vice president of Foreign Policy, and David Victor, one of the world's foremost authorities on the energy sector and on climate governance, the Cross-Brookings Initiative on Energy and Climate mobilizes a core group of scholars with expertise in energy geopolitics, governance, climate economics, sustainable development, energy poverty, urban sustainability, global energy markets, climate governance and regulation, and resource scarcity.

The energy and climate policy world is at a crossroads. With President Trump's decision to withdraw from the Paris climate agreement, we have shifted from a world in which U.S. leadership was a driving force for global action against climate change to one in which leadership is uncertain and diffuse. At the same time, there is a sharp disconnect between the Paris agreement's ambition and the reality of implementing it. Managing the impact of climate change amid a changing energy landscape raises a number of policy questions, including:

- How can governments reconcile the competing objectives of reducing carbon emissions while promoting economic growth and increasing the developing world's access to energy?
- What role does the private sector play in advancing energy transitions?
- How can policymakers help particularly vulnerable populations and industries manage the transition to cleaner and more sustainable energy?
- What tools can incentivize innovation in low-carbon technologies?

Brookings has the research capacity and the relationships to help grapple with these challenges. With overseas centers in China, India, and Qatar, the Brookings Institution is well-positioned to engage with influential actors in parts of the globe that encompass two-thirds of humanity, three-quarters of the world's energy production, and three-quarters of global emissions. Brookings has extensive relationships with executives of the world's top energy producers, governments at the city, state, and federal levels in the U.S. and internationally, and strong working relationships with experts in academia, think tanks, and the private sector.

These relationships allow us to convene a dialogue between the private sector actors with the resources and know-how to drive an energy transition, and the governmental and diplomatic actors charged with negotiating the path forward. The ultimate goal is to provide these decisionmakers with independent and rigorous research while encouraging them to exchange knowledge in support of practical climate and energy policies.

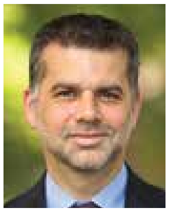
Written Work and Convening Power

The Initiative will publish a series of papers that will disseminate actionable knowledge and proposed solutions to key stakeholders and decisionmakers in both the public and private sector. Reflecting the Initiative's commitment to actionable impact, the papers will offer defensible insight into how real governments, firms, and households will respond to evolving challenges in the global governance of climate change.

The Initiative will also leverage Brookings' unparalleled convening power to organize high-impact public and private events on energy and climate topics, drawing together industry leaders, government officials, and academics. A regular series of roundtables, timed to the production papers in the series, will help forge a network that straddles academe, industry, and government, and bi-annual sessions on the geopolitics of energy and climate will mobilize Brookings' deep strength in geopolitics to bring a degree of realism to bear on energy and climate policy.

Cross-Brookings Initiative on Energy and Climate Scholars

Co-Chairs



Bruce Jones, *Vice President and Director, Foreign Policy*
Jones is vice president and director of the Foreign Policy program at Brookings and a senior fellow in the Institution's Project on International Order and Strategy. He is an expert on multilateral institutions and international order. Jones is currently researching the governance of global threats ranging from climate change to terrorism. He recently co-authored a book about the geopolitics of energy: *Risk Pivot: Great Powers, International Security and the Energy Revolution* (2014).

David G. Victor, *Professor, School of Global Policy & Strategy, UC San Diego*
Victor is a professor of international relations and director of the Laboratory on International Law and Regulation. His research focuses on highly regulated industries and how regulation affects major energy markets. Prior to joining the faculty at UC San Diego, Victor served as director of the Program on Energy and Sustainable Development at Stanford University where he built a research program on the energy markets of the major emerging countries—mainly Brazil, China, India, Mexico and South Africa.

Senior Fellows and Fellows

Amar Bhattacharya, *Senior Fellow, Global Economy and Development*
Bhattacharya's research focuses on the global economy, development finance, global governance, and the links between climate and development. From April 2007 until September 2014 he was Director of the Group of 24, a group of developing country Finance Ministers and Central Bank Governors.

Samantha Gross, *Fellow, Energy Security and Climate Initiative, Foreign Policy*
Gross joined Brookings after 20 years working across sectors, including leadership roles at DOE and IHS CERA Gross's research is focused on the intersection of energy, environment, and policy, including climate policy and international cooperation, energy efficiency, unconventional oil and gas development, regional natural gas trade, and the energy-water nexus.

Ted Gayer, *Vice President and Director, Economic Studies*
Gayer conducts research on a variety of economic issues, focusing particularly on public finance, environmental and energy economics, housing, and regulatory policy. His recent work has looked at domestic and global climate change regulation, the social cost of carbon, and energy efficiency.

Suzanne Maloney, *Deputy Director, Foreign Policy & Senior Fellow, Center for Middle East Policy*
Maloney works on energy in the Middle East and on U.S. policy toward the region. She recently authored a chapter analyzing the impact of Iran's gas sector on the geopolitics of natural gas. Her major projects for the coming year examine the prospects for Iran's reintegration into the global economy and the implications of a changing sanctions regime.

Joshua Meltzer, *Senior Fellow, Global Economy and Development*
Meltzer's work focuses on international trade law and policy issues relating to the World Trade Organization (WTO) and Free Trade Agreements, including the role of energy subsidies and the scope for trade negotiations to address them. His recent research also includes work on sustainable infrastructure.

Todd Stern, *Senior Fellow, Foreign Policy*
Todd Stern is a senior fellow, concentrating on climate change. Stern served from January 2009 until April 2016, as the special envoy for climate change at the Department of State. He was President Obama's chief climate negotiator, leading the U.S. effort in negotiating the Paris Agreement and in all bilateral and multilateral climate negotiations in the seven years leading up to the Paris Climate Agreement.

Adele Morris, *Policy Director, Climate and Energy Economics Project*
Morris's expertise and interests include the economics of policies related to climate change, energy, natural resources, and public finance. Adele joined Brookings from the Joint Economic Committee of the U.S. Congress, where she covered energy and climate issues. Before, Adele served nine years with the Treasury Department as its chief natural resource economist, working on climate, energy, and agriculture issues.

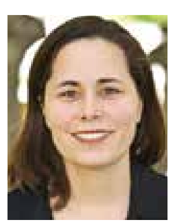
Rahul Tongia, *Fellow, Brookings India*
Tongia is an expert on energy infrastructure, with focus on smart grids. His recent work analyzes the political and technical challenges confronting India as it seeks to increase energy access and improve the reliability of its grid. Rahul also explores opportunities for US-India cooperation on clean energy infrastructure development.

Mark Muro, *Director of Policy, Metropolitan Policy Program*
Muro's recent research investigates funding mechanisms for clean energy finance, including bonds, green banks, utility surcharges, carbon allowances, and taxes. Mark sees nuclear fission as a vital low-carbon energy source & has conducted research on opportunities for US investment in civil nuclear power abroad.

Ye Qi, Director, *Brookings-Tsinghua Center*
Ye Qi is the leading expert on China's environmental policy. His research focuses on China's policies on climate change, environment, energy, natural resources and urbanization. His recent work examines low-carbon development in China. Qi also headed the design of China's first low-carbon development plan, for the city of Baoding in Hebei Province.

Nonresident Senior Fellows and Fellows

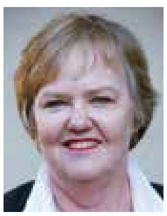
Bill Antholis, *Governance Studies,* studies the domestic politics of energy and climate regulation in the US, the EU, India and China and the structure of international diplomacy.



Allison Anderson, *Center for Universal Education,* focuses on how quality education contributes to sustainable development, disaster risk reduction, and climate change adaptation and mitigation.

Jeffrey Ball, *Foreign Policy,* is an expert in clean energy, energy policy, and finance. He is a scholar-in-residence at Stanford's Steyer-Taylor Center for Energy Policy and Finance and a lecturer at Stanford Law School.

Charles Frank, *Global Economy and Development,* researches the costs & benefits of five low- and no-carbon energy technologies: wind, solar, nuclear, hydroelectric, & combined cycle gas turbines.



Elizabeth Ferris, *Foreign Policy,* was co-director of the former Brookings-LSE Project on Internal Displacement. She researches issues related to displacement, natural disasters, and climate change.

Colette Honorable, *Foreign Policy,* former Chairman of the Federal Energy Regulatory Commission, is an expert on the domestic and international energy sector, and transmission planning.

Nathan Hultman, *Global Economy and Development,* helped develop the U.S. 2015 climate target at the White House. He focuses on national climate target-setting, energy technology transitions & international climate policy.

Warwick McKibbin, *Economic Studies,* focuses on international trade and finance as well as on the economics of climate change. He serves as co-director of the Climate and Energy Economics Project.

Timmons Roberts, *Global Economy and Development,* researches how global North-South relations impact United Nations climate change negotiations as well as the role of foreign aid in the climate negotiations.

Katherine Sierra, *Global Economy and Development,* focuses on climate change issues and policies in the developing world and the effectiveness of climate finance.

Undiplomatic action

A practical guide to the new politics and geopolitics of climate change

David G. Victor and Bruce D. Jones

Introduction and summary

President Donald Trump's June 2017 decision to begin the process of withdrawing the United States from the Paris Agreement on climate change roiled the world of climate politics. We were among those who thought the decision was unnecessary and unwise. But its impact on actual progress toward the goal of minimizing and managing the damages of climate change is easy to overstate. Formal intergovernmental diplomacy has a role to play in shaping energy transitions, but a limited one.

The fact is, deep cuts in emissions of carbon dioxide (CO_2) and other pollutants, as required ultimately to stop planetary warming, requires transformation of energy systems that central architects and standard diplomatic procedures cannot orchestrate. For the foreseeable future, the role of formal global institutions will be limited to setting aspirational goals (most of which will be missed), and focusing attention while mobilizing political energy around the need for serious solutions.

Diplomatic agreements also provide frameworks within which other actors do most of the real work involved in transforming energy systems. That work, for now, mostly involves experimentation and testing of new technologies and policies in local niches. The political incentives for those activities, and the incentives for new technologies to spread more widely, depend mainly on factors far outside the traditional realm of climate policy. Diplomacy can nudge behavior and focus minds. But new facts on the ground—new technologies, business practices, and incentives for transformation—alter the realm of what is politically possible. Although climate change is a global problem, solutions do not require consistent global multilateralism that engages all countries. Nor does it require consistent national policy support. Indeed, most experimentation and testing in the world's largest economies is often distant from central government control. For example, in the U.S., even as the Trump administration unwinds national climate policies, many other jurisdictions within the country are flooding in with their own invigorated efforts.

Here we offer a new political logic to explain how governments, civil society, and firms are grappling with the problem of climate change in an era when the underlying political forces that determine what is possible are erratic, scattered, and in flux. We explain what is happening and also outline how governments, civil society, and firms can build on the momentum Paris has helped to create. We chart a practical pathway through what has become a too-abstract debate between the realities of modern energy systems and the ambitious aspirations of deep decarbonization. Aspiration is not the same thing as realism about consumers' actual willingness to pay for energy shifts, and about the political obstacles to action and the political conditions and coalitions needed to overcome those obstacles. For non-state actors, in particular, momentum and aspiration have generated massive efforts aimed at changing the politics of climate change. What is needed is a framework for understanding when those efforts will work and how they can find key pressure points. For firms within the energy industry, our framework helps explain how to invest around topics that are existential to the industry, yet do not have reliable political signals about what to expect on the same long timescales that are relevant to energy infrastructures.

The logic we offer is based on the idea that for nearly all countries and firms, climate change goals are not a central driver of change in energy markets and geopolitics. Instead, the reverse is true—protecting the climate is one of many policy goals often buffeted by larger trends in political interests and technology. Diplomacy largely follows and reacts to those deeper, fundamental political and economic forces. Top-level political leadership can make a difference in shaping societal and global expectations—as President Barack Obama did with sustained high-level political engagement on the climate question, or as the French government has done in the run-up to the Paris Agreement and its aftermath. Even then, such bouts of leadership can, at best, raise a curtain and focus attention on a stage set by others. The underlying facts surrounding practical deployment of new technologies are what drive changes in emissions, political preferences, and how national governments assess national interests. Those underlying facts—and how innovation, often directed toward decarbonization—are what determine the main shifts in energy systems and their emissions. Over time, this pattern of fundamentals first and diplomacy last may reverse, with climate change diplomacy and policy eventually becoming a more decisive driver of change in its own right. But for the foreseeable future, especially in the U.S. and nearly all other large economies, the underlying facts on the ground matter more than diplomacy.

Given these realities, we develop here an argument about what we call "episodic multilateralism." The conditions for genuine global alignment on climate and energy issues across many countries are likely to be rare and fleeting. In between episodes of global diplomatic agreement, we argue that the conditions for the most transformative changes arise through action in niches and by small groups that are focused on technology and policy innovation. The key to understanding how policy and diplomacy evolve lies with understanding how these small groups and niches arise, and why they invest in practical problem-solving.

We write with several audiences in mind. For firms, we offer roadmaps for understanding how policy may evolve on a topic where there are huge differences around the global market and where sifting reality from political aspiration is essential. For diplomats and other policymakers, we offer some sobriety about what really matters and where leverage is possible. For civil society, we suggest some ways to channel political energies, which are becoming much more organized in the aftermath of Paris, into leverage on the problem of emissions. And for all, including academics who study these questions, we focus on the frontiers—four of them, we find—that are the places to watch and work in accelerating the transformation of global energy systems. Those four frontiers are:

- First—rather than a constant focus on climate change as a truly global problem, we highlight the reality that the vast portion of emissions growth comes from a handful of jurisdictions. It can be much easier to organize efforts in these jurisdictions—working in clubs, rather than large multilateral institutions. We see important clubs at the intergovernmental level—such as efforts involving the U.S., China, and India. We also see the emergence of non-state clubs of firms and sub-national governments. That clubs exist is hardly a new insight. What is new and looming as the central challenge is figuring out which of these clubs actually matter. There are tens of thousands of initiatives now focused on climate change, and separating signal from noise is the challenge. Many are called; few are chosen.

- Second—a focus on what we call "high leverage points," i.e., places where short-term action will generate tangible rewards. Tackling CO_2 emissions has proved difficult because big cuts implicate economically and politically expensive action now with measurable gains only materializing much later and diffused across the globe. A bigger emphasis on short-lived climate pollutants like soot and methane can change this calculus because such pollutants typically cause direct harm (e.g., to human health), which amplifies the benefits of control, and short lifetimes in the atmosphere also shorten the time between incurring the cost of cutting emissions and the appearance of politically useful benefits.

- Third—a focus on pivotal technologies. For emissions, the key technologies are related to electricity and transportation. Nearly all studies show that deep decarbonization is best achieved with deep electrification. And in countries that have done the most to control emissions from electric power, the one sector that has proved hardest to tame is transport. Absent profound technological change—especially in electricity and transport—deep decarbonization will remain politically impossible because important governments and their political constituencies will see transformation as expensive and not worth the cost.

- Fourth—using episodes of diplomatic agreement to lay the foundation for deeper cooperation. In the past, most environmental diplomacy has addressed problems that have proved relatively easy to solve, and thus there have been few fears that countries will not honor their agreements. By contrast, in most other areas of international cooperation—such as trade, investment, and arms control—those concerns have properly led governments to invest heavily in monitoring and enforcement. Deep cooperation on climate change will require the same, and the foundations for well-monitored, politically realistic, deep cooperation can be laid now.

This paper is neither a dirge nor a call for passivism. Shifting the focus to niches, to innovation, to small groups that can drive action—all of this is part of creating the conditions under which it is realistic to shift policy, both national and global, through which deep transformation of energy systems will occur.[1] Over the rest of this essay we outline our case in two major steps. First, we explain why episodic multilateralism is how climate diplomacy is likely to evolve. Second, we explore what this logic means for firms, governments, nongovernmental organizations (NGOs), and others that are trying to alter this system—so that diplomacy is more effective, investments in deep decarbonization are more profitable, and policy is more responsive to the underlying realities of how energy systems operate.

Part I: Rightsizing the roles for diplomacy

In recent years, the public debate about climate change in diplomatic circles has hewed closely to the question of whether leaders would be able to agree on an inclusive global agreement and then implement it. We were among those who celebrated the conclusion of the Paris Agreement.[2] But achievement of the Paris goals was always going to require much deeper changes than diplomacy alone could deliver.

Here we offer a view about how progress on energy transitions can emerge. International institutions and individual leaders matter. But much more important, in our view, are the underlying forces that create incentives for firms and governments to test and deploy new technologies that will transform the world's energy systems.[3] Essentially, all the major sources of emissions—energy systems, notably, but also the built infrastructure and agriculture—are highly decentralized activities with strong lock-in effects. They are hard to steer via weak global agreements. Moreover, diplomatic agreements arise through slow processes and yield outcomes in episodic spurts that offer only periodic guidance.[4]

This view suggests that all the efforts of governments and diplomats should be viewed through the lens of whether they alter the underlying economic and political structures of energy systems and other emitting activities. From that perspective, governments have some direct leverage. They are large consumers of energy themselves and operators of state-controlled power grids, fleets, and public lands. The U.S. government, itself, has spent $10-20 billion per year on energy services over the last decade.[5] Governments can influence prices and price signals through use of public lands, through contracting decisions, through regulation and other market interventions, and through taxation. But government action is not as simple as designing good policy; governmental action is above all political. To understand effective pathways for energy transitions, we have to consider how the shifting interests of organized political constituencies, including voters, alter how government behaves and how those shifts in behavior alter the content of both policy and diplomacy.

This perspective may be particularly germane during the presidency of President Trump. While the Trump administration shows hostility to cutting emissions through federal policy, the practical relevance of the federal government is easy to over-state. For instance, for all the apparent interest within the Trump administration of advancing conventional coal, market forces created by inexpensive natural gas and improving renewables make it hard to see that the decline of coal (and its emissions) will reverse.[6] Within the U.S., many states and localities are moving faster with their own climate and energy policies—spurred, in part, by the conspicuous hostility to this topic in Washington.

The situation in the U.S. is far from unique. Across the industrialized world, even governments that have bold visions for cutting emissions, which all governments announced in the context of the Paris Agreement, are falling short.[7] And across the emerging economies there are big changes in emissions—mostly reductions compared with expected levels—due to forces unrelated to climate policy.[8]

This section aims to explain why nearly all countries, including the U.S., approach the mission of deep decarbonization tentatively. Under political pressure, they announce bold goals but are not sure what they can implement. Real patterns of investment in new technologies and business practices change in halting ways that rarely align with bold goals.

We first explain why it is difficult to create strong political support for costly climate policy within most countries and jurisdictions. The explanations are familiar, but we also explain where and how niches arise and societies do invest in emission reductions. The politics of deep decarbonization are hard and well-known, but the deviations from that rule are much more interesting and important to explain.

Second, we explain the patterns of multilateral diplomatic activity that emerge from these deep-seated difficulties in mobilizing and sustaining broad-based political support in many countries. It will be relatively rare, we argue, for many different countries' national political systems to line up in ways that allow for meaningful international agreements. These fleeting periods of alignment can be captured in a process of global cooperation that we call "episodic multilateralism."

Explaining and overcoming the difficult politics of decarbonization: Niches and co-benefits

Stopping climate change is fundamentally about decarbonizing the world's energy system. Many different pollutants cause climate change, but for the long-term health of the planet, one pollutant is most pivotal: carbon dioxide. About 14 percent of CO_2 emissions come from changes in land use—notably deforestation—which have gone flat over time. Essentially all of the remaining CO_2 emissions come from the energy system.[9] Averaged globally, these emissions are still rising.

Because CO_2 has a very long residence time in the atmosphere, stopping the buildup requires very deep cuts in emissions—about 80 percent around mid-century.[10] Absent technologies that remove CO_2 directly from the air—which are feasible, but extremely costly at present[11]—the geophysical nature of this main pollutant requires that the energy system become nearly fully decarbonized.

The politics of decarbonizing the world's energy system are extremely difficult to manage. In most advanced industrialized countries, nearly all energy decisions occur in the private sector. The price of fuels emerges from competitive markets; actions that raise the price of energy are highly visible politically, which can make it difficult to mobilize and sustain coalitions of voters and firms needed for costly change. The energy system depends on infrastructures—power lines, pipelines, shipping networks—that are expensive to build, require long periods of operation for recovery of costs, and thus change slowly. Some of these are amenable to policy shifts or regulation by governments; others are a function of long-term investment cycles by myriad private sector actors.[12] In addition to physical inertia, there is often strong political resistance to costly and rapid changes. Altering the trajectory by investing in alternative technologies is initially hard because well-established interests—producers and consumers—resist change that is costly for the incumbents. For all the firms that see opportunity, there are many other incumbents that can readily organize to block change.

In parts of the world where state-owned enterprises lead the energy sector—and therefore governments, in theory, are more firmly in control—the politics are no more fortuitous for rapid decarbonization. Some state-owned firms have led the rapid deployment of nuclear power (e.g., KEPCO in South Korea, EDF in France); others have overseen rapid deployments of some renewables (e.g., Huaneng and some provincial power companies in China) and gas (e.g., Pemex in Mexico, Statoil in Norway). But the carbon intensity of state-owned energy firms on average remains high, and operational efficiencies, in general, are low. While climate change has been on the agenda for three decades, almost no state-owned energy firm has been in the forefront of efforts to decarbonize, with Norway's Statoil as the only major exception,[13] along with possibly Saudi Aramco, as founding members of an industry-led effort to invest in low carbon emission technologies.[14] Rather, detailed research on the politics of state-owned firms has tended to emphasize that they are "states within a state"—organized politically and economically to favor the status quo.[15]

Politically, the energy system is wired to avoid disruptive change. Nonetheless, within that system prone to stasis, there are pockets—at first shallow and narrow, later deeper and broader—where deeper cuts in emissions are feasible.

Many of these niches open for reasons that have nothing to do with climate change. The spread of nuclear power to Abu Dhabi—which will commission four new reactors starting in 2017 through 2020—is driven by a desire to diversify the local energy system and cut the cost of an energy supply that previously came from burning local oil. In India, the national government and some state governments are re-invigorating efforts to produce and pipe natural gas—an activity that requires foreign investment and politically difficult choices such as allowing producers to charge full costs. India is doing this mainly to diversify its energy system and to reduce local pollution from coal and dirty petroleum-based transportation fuels.

A smaller but growing number of pockets emerge due to policy choices motivated by concerns about climate change—for example, the expansion of renewable power in Germany or California. Through familiar processes of innovation and improvement by scaling, these early pockets lead to better performing technologies, as well as more powerful interest groups favoring change.[16] The earliest German solar energy policies were backed by a thin alliance of researchers and futurists; as solar and wind power became more ubiquitous, the coalition spread to include the mainstream of most of German politics.[17]

Some firms also find themselves focused on climate change because they face severe consequences if they fail. Oil and gas companies, mainly those based in Europe, fear erosion of their licenses to operate. There is a steady drumbeat of related pressures—from direct legal action against firms, to shareholder requests for disclosure, and potentially new requirements for firms to conduct extensive analyses of their exposure to climate risks and policy.[18]

Fortuitously, most efforts to control local air pollution, improve energy security, and address other problems with energy systems also yield reductions in CO_2 and other warming gases. Indeed, most of the emerging economies have made pledges on climate policy that do not require much or any extra effort because they are rooted in big changes in energy policy that the country and its firms are already planning.[19] Particularly striking are broad-based political coalitions in India and China that support action to deal with air pollution—these are politically powerful forces because they are anchored in solving tangible local and regional problems, not because they encompass deep decarbonization.[20] In most of the world, deep decarbonization remains an elite topic associated more with canapés in Davos than the plight of the 99 percent.

The logic of episodic multilateralism

Political support for cutting emissions is weak and erratic—concentrated in a few jurisdictions that are still at the early stages of figuring out what is possible and what it will cost. Those include, for example, parts of Europe, the coasts in the U.S., portions of Japanese industry, and elements of large emerging economies—such as China's push on electric vehicles and renewables, India's ambitious plans for solar power, and Brazil's program to reverse deforestation.

Not surprisingly, these fundamental patterns have an effect on international cooperation, which is hard to organize and sustain—a process we will call "episodic multilateralism." Over time, the process of cooperation will become less episodic and erratic and more regular; cooperation will deepen as more jurisdictions learn what is feasible and confidence grows that each is doing its part. For now, however, the dominant harmonics are episodic.

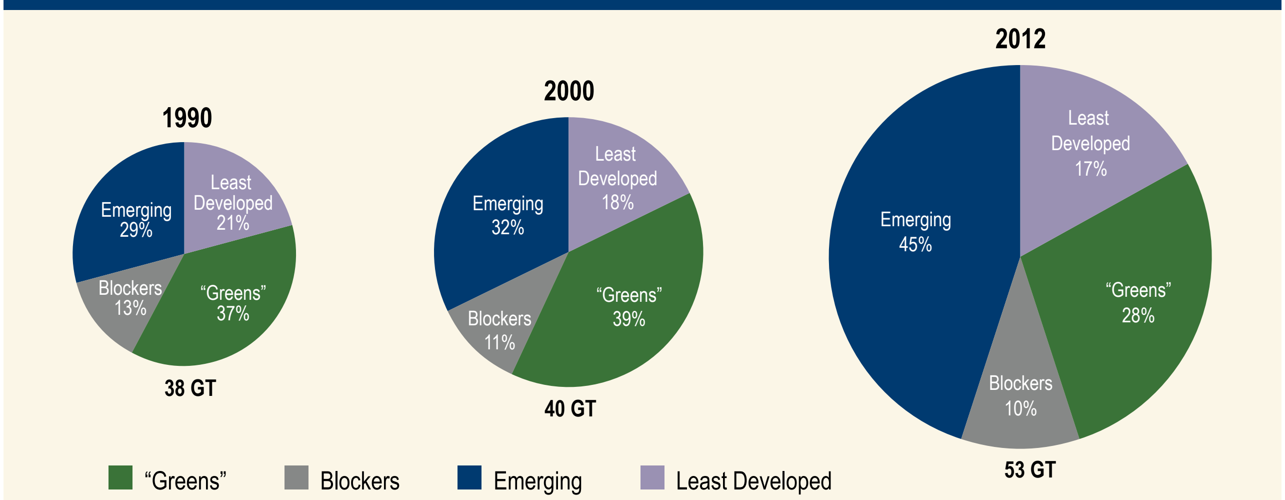
The roots of episodic multilateralism lie in the fact that different populations frame the climate problem in very different ways because many believe that the most serious actions to control emissions are rooted in other more pressing policy goals. In addition, support for policies will vary over time since it is often affected by exogenous events that come and go—for example, extreme weather or catastrophes that focus minds on environmental problems. Within countries, there is also likely to be variation in policy support. Indeed, the bigger the country, the more varied its domestic politics. In the U.S., for example, perhaps only half a dozen states reliably support decarbonization—all are wealthy, coastal states, and nearly all vote reliably for one political party (Democratic) and therefore are often excluded from the national ruling coalition. In many more states, the politics around climate change are constantly shifting, even though particular cities remain more committed to global warming efforts—for example, the deep green city of Boulder within the purple state of Colorado or the green city of Austin within the red state of Texas.[21]

When diplomacy on climate change began in the early 1990s, this tremendous variation in the underlying framing and political support for policy might not have mattered as much. That is because, as shown in Figure 1, a sizeable fraction of emissions—perhaps two-fifths—came from "green" countries of the Organization for Economic Co-operation and Development (OECD) whose populations, to varying degrees, had significant and growing concern about climate change. By 2000, emissions from those countries flattened, and in the period since then, emissions across the "greens" have declined substantially for various reasons.

Today, essentially all growth in emissions comes from countries that are more reluctant to spend their own resources addressing global problems—that is, the emerging economies such as India and China. Today, much more than in the 1990s, when the United Nations Framework Convention on Climate Change (UNFCCC) was crafted, serious diplomacy around climate change must contend with the reality that most of the emissions comes from countries that will have shifting and erratic support for emissions control. Worse, the fraction of global emissions from very poor countries—due mainly to agriculture (a big emitter of methane) and deforestation—remains nearly one-fifth of the global total. These countries are much more focused on urgent development needs. And the share of emissions from large hydrocarbon exporters—Russia and the Persian Gulf, mainly—has virtually not changed at all.

A few countries—mainly in continental Western Europe—are run by governments whose main political parties are reliably focused on the mission of stopping global climate change. Unfortunately, these highly enthusiastic countries are a small and declining fraction of global emissions. Because they are mature, efficient economies, their emissions do not grow—a pattern reinforced by the policies they adopt.One of the great ironies in the geopolitics of climate change is that as a jurisdiction becomes more committed to addressing the problem of emissions, its direct leverage on the problem shrinks. For example, the 11 Western European countries that have long been the main drivers of global climate change

Figure 1. A political perspective on the changing shares of global emissions



Pies show the fraction of global greenhouse gas emissions (all gases, including land use change). 2012 was the most recent year for which there are essentially complete data. Wedges show emissions from (a) "green" countries that have tended to adopt climate policies mainly for reasons of concern about climate change; (b) emerging countries that are increasingly concerned about climate change, but whose emissions policies were motivated principally by other concerns such as local air pollution; (c) the least developed countries that have much more urgent local development priorities and relatively small energy-related emissions (although often high emissions from land use and agriculture); and (d) the big carbon-exporting countries that have incentives to block strict limits on emissions.[22]

diplomacy accounted for 11.4 percent of global emissions in 1990, a share that has halved to 5.7 percent in 2015.[23] The deep "green" countries have a keen interest in doing something about the climate problem, yet have little or no capacity to affect the problem through their own actions. For leaders, solving the global problem requires followers.

Part II: Rethinking diplomacy and what matters

Episodic multilateralism is a reality. In this section we explore what classic diplomacy can achieve in this context. There are places where diplomacy matters, but it is crucial to understand where and how diplomatic action, including formal intergovernmental agreements, will affect the markets, choices of technology, and behaviors that ultimately cause emissions.

Politically, the challenge of creating effective systems of governance follows the logic of fractals. At the most global level, governing systems are weak but can exert some leverage. Zoom in a bit to macro regions and the same pattern replicates. Zoom still further to nation-states and a similar pattern appears—all the way down to local levels where real firms invest in real projects.

At the global level, broad governance systems are good at setting goals but often poorly suited for the detailed spadework of implementation. These governance systems are weak because they require consent from essentially all nation-states before they can operate. This consent process is not completely impotent—in setting technical standards, for example, consensus processes have had large impacts in marine shipping, aviation, consumer goods, and other elements of the energy industry.[24]

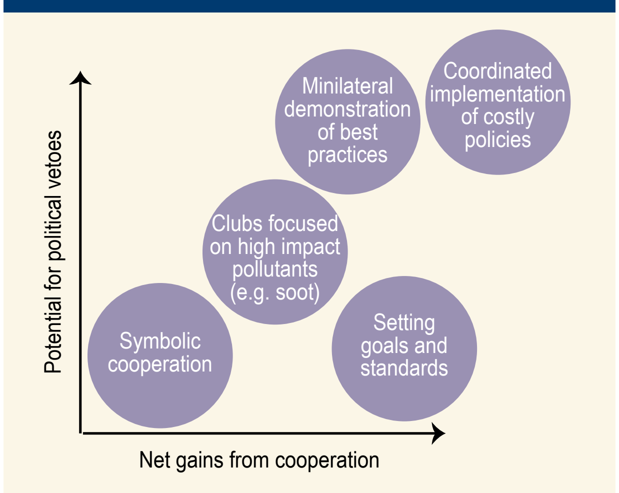
At the regional and national level, governing systems are often stronger. They are good at some things—such as setting the standards for national electric power grids and fuel markets—but also poor at managing implementation in the small niches where radical innovation and deep decarbonization begin. That logic carries on down, partially replicating itself at each fractal level. Because competence telescopes down to very local levels, one of the central challenges in building an effective system for governing climate change is to strike a balance between the intense "bottom-up" process of innovation and the more traditional "top-down" process of formal diplomacy.

Creating and sustaining the mechanisms for cooperation can be costly, so close attention is needed on the net benefits. Those net gains are shown on the horizontal axis in Figure 2, below. And because much of the international cooperation related to climate change arises in institutions that require various degrees of consensus, attention is also needed on the potential for important countries to block agreements and their implementation, a property shown with the vertical axis in Figure 2.

It is relatively easy to gain agreement on symbolic cooperation—for example, communiques that will have little practical impact on behavior because they are worded generally and yield few consequences if not honored. Those agreements may nonetheless have some value in framing topics for debate and signaling points for coordination. It may also be relatively easy (but not trivial) to agree on common goals and standards—such as the overall ambition for international cooperation, standards, and timetables for reporting—especially when goals adopted are not strictly enforced.[25] The Paris Agreement contained elements of both of these types of cooperation—especially as shown in the lower right corner of Figure 2. It set ambitious common goals (stopping warming at well below 2 degrees Celsius above pre-industrial levels, for example) without much individual accountability. Achieving an agreement in Paris was far from trivial, and once that agreement was achieved, its main benefits persist. What may prove particularly important on an enduring basis is the way that high-level political mobilization around Paris caught the attention of C-suite actors in the private sector, elevating climate and sustainability questions away from corporate social responsibility approaches to central matters of strategy and enterprise risk, requiring continual attention from top executives and boards.

Moving from left to right—toward agreements that, themselves, have a greater potential impact on behavior—generally requires moving vertically as well. The central challenge for diplomacy as it becomes more effective is that such activities, especially formal agreements, face much greater risks that dissatisfied parties will block them. As gains rise, so do costs, and in international diplomacy those costs are usually reflected in more countries being able to block agreements and action. This is why so many analysts are intrigued by the opportunities to work in small groups—in clubs—where it is possible to tailor membership to focus on areas where joint action is possible and on topics, such as regulating soot and other noxious pollutants, where joint gains are large.[26]

Figure 2. Net benefits of creating and sustaining cooperation versus ease of adoption



Following the fractals, the same logic applies to large federal systems—such as India, the EU, the U.S., or Brazil—where central administrators are relatively weak while state and other decentralized authorities have formal administrative control and many veto points. The logic also probably applies to de facto federal systems, such as China, where there is strong central administration but the sheer complexity and political difficulty of planning and implementing transformative change means that provincial and local authorities have a lot of leverage (even vetoes at times) over outcomes.

This logic sets up the strategic choices for countries that want to advance climate policy. They can emphasize the pursuit of aggressive international cooperation that offers the largest potential for joint gains; put differently, they can double down on Paris and emphasize the centrality of diplomacy in solving the climate problem. Our argument is that such efforts—that is, "diplomacy first"—comes with the near guarantee of substantive failure because there are deep structural impediments to success. Further symbolic gains might be recorded, after much laborious diplomacy, but these are unlikely to yield real changes in underlying policy and emissions in the absence of (a) major political change in the reluctant major economies and (b) proven new technologies and technological-industrial models for energy production, transmission, and consumption. The vertical axis on Figure 2 is treacherous to travel without new facts on the ground that weaken political resistance to change and reduce the number and strength of players that want to veto such efforts.

The political logic of episodic multilateralism also helps to explain why diplomatic goals, usually, will be misaligned with realistic outcomes. Leaders of diplomatic processes know that the opportunities for agreement are fleeting and are under pressure to demonstrate results. Accountability is low, especially for the most distant and ambitious goals. This problem is now abundantly apparent under the Paris framework where national efforts are not enough to stop warming at the widely discussed goal of 2 degrees Celsius. For diplomatic insiders, all of this is evidence of the need for more "ambition"—that is, stronger pledges and doubling down on the Paris process. Indeed, when the Trump administration flirted with the idea of softening the U.S. pledge, pro-ambition forces around the world labored to argue that pledges, under Paris, could only ratchet tighter.[27] Indeed, the belief in this logic around legal ambition is so strong that the Paris process has asked for input on even more aggressive goals, such as stopping warming at 1.5 degrees Celsius.[28]

To us, the reality of falling short in meeting long-term goals is evidence that the underlying political structure of the climate change problem—that is, what veto-prone governments and diplomatic processes can realistically accept—does not yet allow for deeper cuts. Improving that structure requires focusing on the points of leverage—the niches and the rate at which new technologies and policy instruments pioneered in those pockets spread more widely.

The degree of transformation needed for deep decarbonization cannot be planned from central global mandates. Instead, solutions hinge on implementation, and nobody knows which approaches will work best. A multiplicity of efforts in different political niches test out ideas and help determine which approaches work and will scale. The evidence suggests four core aspects to this.

1. Focus on the actors that matter, and work with them in small groups.

Although climate change is a global problem, solutions do not require consistent global multilateralism that engages all countries. Already over the last three decades of efforts to address the climate problem, cooperation has been highly fragmented and pursued through overlapping institutions rather than just unified global frameworks. Indeed, cooperation in small groups—clubs—can be more effective than efforts to forge global deals. Even during the tenure of President Obama—a president who was motivated to tackle climate change and ideologically predisposed to multilateralism—what emerged was not a formal system of highly structured cooperation through universal institutions, but rather a patchwork of club-based action through the G-20, the Major Economies Forum, the Clean Energy Ministerial, and similar fora. Deals worked out in these smaller forums where cooperation was easier to engineer set the agenda for the Paris deal. Most striking was the U.S.-China bilateral relationship, which led both countries to make mutual pledges in 2014, which had the intended effect of shaping the similar pledge-based process agreed a year later in Paris.[29]

Looking to the future, there's a need for greater focus on smaller groups. Those include the G-7, which can help keep key Western countries on track in terms of political commitments to overarching targets and innovations on climate finance.[30] They also include the G-20, which has begun to explore more serious action on fossil fuel subsidies, and is the locus for coordination of investments around infrastructure—a trillion dollars' worth of it—with major implications for energy pathways. Another potentially important small group is the Major Economies Forum on Energy and Climate (MEF), which emerged in 2009 out of the ashes of an often-derided Bush administration initiative, the Major Emitters Forum, and which has developed broad support from within its 17-strong membership. It divides its efforts between an action agenda ("concrete efforts to accelerate the transition to low-carbon economies" in areas such as energy efficiency in buildings) and attempts to create the political conditions for agreement though the UNFCCC process.[31] While it would be wrong to see the MEF as a competitor to the UNFCCC, any forum whose members account for three-quarters of global emissions has the potential to play an increasingly important governance role. What remains unclear at this writing is how these clubs will grapple with climate issues given the testy relationship between the Trump administration and seemingly all multilateral institutions of any shape and size. Some of these efforts may hibernate or move into Track 2 mode for a while, but the foundations remain in place for progress in such settings. In the short term, for example, the G-20 and G-7 seem likely to place less focus on climate change, to avoid a hard clash with President Trump.

There are also new clubs aimed at fostering investment in renewables (e.g., International Renewable Energy Agency) as well as some initial (though very small) efforts at transit efficiency (e.g., the Global Fuel Economy Initiative and International Council on Clean Transportation). The U.S. also has attempted to structure its bilateral climate cooperation around concrete initiatives; this is especially true with China, where the U.S.-China Climate Change Working Group focuses on smart grids, carbon capture and storage, vehicle emissions, energy efficiency, and sharing data.[32] Most institutions perform poorly when they are monopolies. The multiplicity of efforts—partially overlapping, partially complements, and partially competitors—help create a more diverse ecosystem for experimentation and weeding out what works.

Even more interesting, perhaps, are the "three-dimensional" coalitions that are now emerging—groups of political actors that cover (two-dimensionally) many places on the planet as well as (vertically) cover national and sub-national levels of government.[33]

The activities of cities could become an important new domain for cooperation within and across countries. The growing majority of energy consumption and carbon emissions is located in major cities. As a general rule, most innovation also happens in cities, and in the U.S., major cities are more closely aligned to climate-friendly politics than their broader state-level political units. Upward of 67 percent of American economic activity and energy consumption, for example, took place in cities that voted heavily Democratic during the 2016 election.[34] Many of these cities have joined other jurisdictions to make declarations of support for deep decarbonization. For example, the "Under 2 MOU" now includes over 200 supporters—from California to New South Wales, Alsace to East Kalimantan—each pledging to adopt policies consistent with stopping warming at 2 degrees Celsius and thus undertaking deep cuts in emissions. Whether these city and other planners have real choices that could shift the overall energy mix or will implement those choices remains to be seen.[35]

2. Focus on high-leverage emissions: Short-lived climate pollutants

The geochemical attributes of CO_2, the protagonist in the story about long-term changes in the climate system, are politically very inconvenient. Because the pollutant is long-lived, the benefits from costly efforts to control emissions are diffused far into the future and across many countries. Concentrated costs and diffuse benefits are usually not recipes for successful cooperation, and it is not surprising that progress has been difficult.

Short-lived climate pollutants (SLCPs) could be different for two reasons. First, these pollutants have much shorter lifetimes, and thus the benefit from action is larger and appears faster than the benefits from efforts to control long-lived pollutants—an attribute that makes their economic net present value higher and their value to current politicians even higher. Soot has an atmospheric lifetime of about a week, for example, and yet is a major cause of climate warming.[36] For physically large countries, this short lifetime means that many of the effects are felt within the country itself and not just diffused to others. For example, in the Arctic region, a major impact of soot emissions is the extra warming and melting of ice caused by soot deposits (which are dark in color) on ice (which is bright and otherwise reflects away much sunlight, rather than absorbing the solar heat). Russia, Canada, and others suffer significant harm from their own soot emissions partly for this reason. India, as well, suffers more melting of valuable Himalayan glaciers due to soot deposition on the ice from its own emissions.[37]

A second reason that these pollutants are attractive, politically, for action is that they cause many harms in addition to climate change. Methane, which has an atmospheric lifetime of a decade or so, is a precursor to atmospheric pollution—notably ozone in the lower atmosphere, which harms human health and crops. Soot is a big direct killer—a leading cause of air pollution-related diseases—and also has indirect effects on other pollutants. Thus governments and communities that might otherwise not care much about impacts on the global climate might nonetheless care about these pollutants that cause large harm to human welfare. Indeed, new modeling work suggests that for many countries, the impact of SLCPs on health and crops (especially health) is much more important than the impacts on climate.[38] And in highly sensitive regions—notably the Arctic—these pollutants can have a very large impact on the climate.

Tremendous leverage is possible for SLCPs, and that leverage could be highly compatible with the incentives of key countries. Some new institutions have emerged with a focus in this area. Most notable is the Climate and Clean Air Coalition (CCAC) to Reduce

Short Lived Climate Pollutants, a club of countries, NGOs, and international organizations organized to analyze and act on the potential to tackle methane, black carbon, and hydrofluorocarbons (HFCs).[39] It is disturbing to see, however, that the CCAC has been expanding in size—making the effort more diffuse and bargaining more complex—rather than staying focused on what a smaller group can achieve. There is a strong tendency in diplomacy toward inclusiveness, which is admirable in theory, without as much attention to needed strategy.

Today, probably the best example of a country that is acting on SLCPs for reasons of self-interest—and fortuitously helping to protect the planet—is China. While some realism is needed on just what China is willing and able to achieve, there is no question that noxious levels of local and regional pollution are focusing political pressure on the Chinese governments—at the central, provincial, and local levels—to cut emissions in ways that are also reducing the country's overall impact on long-term global warming.[40] Total coal consumption in China is set to level out about now, with total warming emissions not far behind. Older coal plants are being shut and replaced with newer ones that are much more efficient and kitted with extensive pollution control equipment.[41]

3. Focus on high-leverage technologies: Deep decarbonization will require technological transformation

Applied to climate change, what matters for progress is not more diplomacy, but tangible investments in technologies that reduce emissions. Here, specific reduction commitments will be much less important than demonstration/deployment of particular technologies—whether for carbon capture and storage or renewables—as well as practical business models that allow firms to profit and supportive interest groups to emerge. Confidence in the performance of these new technologies creates new facts on the ground—new confidence that deep decarbonization is possible at a reasonable cost. Deployment of these technologies will help catalyze interest groups that coalesce around the need for more effort.

A spate of studies has shown that deep decarbonization will require massive technological transformation.[42] Although some research suggests that the needed technologies are at hand, the best analysis makes it clear that massive innovation will be required. Figure 3, excerpted from the latest Intergovernmental Panel on Climate Change (IPCC) report, shows the differences between standard baseline scenarios for future emissions in which countries do not adopt substantial new policies (gray lines) and those in which countries deploy existing, known technologies and practices to improve energy efficiency (purple lines). Such efforts can plausibly stop growth in emissions, as evident, for example, in China where the emissions curve is now flattening.[43] But deep cuts in emissions consistent with stopping global warming (green lines) require much more complete and massive transformation.[44]

Because innovation is pivotal, it is important to understand the political underpinnings that lead governments to invest in innovation and to coordinate their innovation policies. And it is important to understand where and how those governmental activities intersect with the private sector investments in developing and deploying new technologies.

For the first two decades of climate diplomacy, there was almost no sustained attention to the need for explicit technology innovation strategies. Most diplomacy focused just on emissions. On the surface, things are now changing. In Paris, governments announced Mission Innovation, an effort that includes 22 countries and the European Union that have pledged to double public sector investments in clean energy research and development over five years. A big effort to boost private sector investment in new energy technologies was also, in part, catalyzed by the focus on climate change created by the Paris process.[45] While fresh attention to innovation is welcome, the same perverse logics of diplomacy are now playing out in innovation. Governments have proved adept at making bold statements, but the underlying patterns in policy and behavior have not yet changed. While many promising technologies are emerging, direct policy efforts to achieve massive innovation remain erratic and weak.

Nearly every major success in international environmental diplomacy has been rooted in confidence that the major countries could implement strict international commitments at an acceptable cost at home. The ozone layer accords, for example, were the epitome of deadlock and thin symbolic agreements—similar to climate today—when the major emitters thought that deep cuts in emissions would be expensive. New facts—in that case, new technologies along with new political supporters—made it possible to move quickly from the symbolic achievements in 1985 of the Vienna Convention, to the numerical cuts agreed in 1987 in the Montreal Protocol, to even deeper cuts agreed in 1989 and periodically in the years since.[46]

In the realm of energy-related emissions, some of the pivot points depend on key technologies and fuels. One technological example is pervasive electrification—including of the vehicle fleet—which could allow rapid and complete decarbonization of the energy system.[47] Already some niches are emerging for electrification—in California, Norway, and now in countries such as France and Britain that have announced bans on new internal combustion vehicles that will take effect over the next few decades—but it is important to assess how quickly (and at what cost) this electrification will unfold in the real world. This is not the first time governments have tried to impose quotas on internal combustion vehicles, only to find that the technology and markets were not ready. Also important is to assess areas of the energy system, such as freight and air travel, where electrification seems more remote.

Figure 3. Transformation of the global energy system

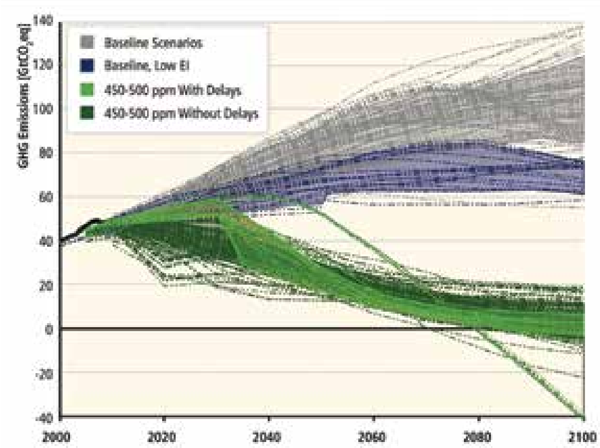


Figure 3 shows all published emission scenarios reviewed in the 2014 IPCC report. See IPCC, "Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change," (Cambridge: Cambridge University Press, 2014), http://www.ipcc.ch/report/ar5/wg3/. Gray lines are baseline scenarios. Purple lines are baseline scenarios with varying degrees of incremental change in energy efficiency. A huge gap remains between those scenarios and the green lines that offer a better-than-even chance at stopping warming at 2 degrees Celsius. Excerpted from Figure 1.9, David G. Victor et al., "Introductory Chapter," in "Climate Change 2014: Mitigation of Climate Change: Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change," IPCC (Cambridge: Cambridge University Press, 2014), http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf.

Many new facts on the ground are coming into focus. Battery technology, for example, is improving at a pace that is among the most rapid for any major energy technology in recent decades.[48] Improved batteries could have a keystone effect for energy systems—enabling more responsive demand for electricity, more reliable integration of renewable power supplies, and a shift to electricity and away from oil for transportation. All of these changes, if handled well, could facilitate deep decarbonization.[49]

Some of these new facts will emerge autonomously, or through a combination of autonomous technological change and policy. Some hinge on active policy support—and the political coalitions that sustain it.

Of course, a given technological advance can also have unforeseen economic and political effects. These also evolve over time. For example, important advances in the technology for fracking have seen a transformation of first U.S. and then global markets for natural gas, driving natural gas prices sharply down. Initially, many climate and energy scholars believed that natural gas could serve as a bridge technology, cutting emissions by important amounts while still-lower emissions technologies matured. As low prices for gas endure, however, there is growing evidence that suggests that natural gas will emerge less as a bridge and more as a cul-de-sac unless the industry does more to control emissions associated with gas.

4. Build foundations for better governance

Above we have focused on tangible actions that could deliver large leverage on the problem. All of them are in the spirit of changing facts on the ground in ways that reduce emissions and also make a more favorable political economy for new policies and industries to emerge.

Eventually, if such efforts are successful, a more favorable foundation for international cooperation will be laid. Within countries, the interest groups around emission control will no longer be allied mainly to raise flags about the cost of such action. Real world demonstration projects will give incumbent firms more confidence about their role in a decarbonized future and will offer catalysts for new industries. The elements of that world exist in some places, but they are not pervasive and are still fragile politically. Many activists are impatient about getting to that future more quickly, and there are important questions about whether the whole process could be put on steroids. We are skeptical. The business of changing energy systems and changing how people and firms view what is feasible for their long-lived infrastructure is a slow business.

Making the most of that more fortuitous future as it unfolds requires some planning right now. In particular, it is instructive to compare the experience with international environmental diplomacy—where countries are simply expected to comply with their obligations—with arms control, trade, investment, and nearly every other major area of international cooperation where compliance is not assumed. In many of these areas the parties to prospective international agreements invest heavily in information exchange provisions, confidence-building, procedures to facilitate independent monitoring, and resolution of disputes.

In climate, very little of this has happened. There are some provisions for information exchange, although there are ongoing debates about the quality of the data. The Paris process set up a pledge and review system, but the quality of the Nationally Determined Contributions (NDCs) is highly uneven and serious review mechanisms do not yet exist.[50]

The Paris system offers a good, if incomplete, framework for building a verification system. Stronger incentives are needed for countries to reveal more accurate information about the policies they are actually implementing, and which ones work. That will require that some countries volunteer for significant reviews of their Paris pledges. Those volunteers should also commit to adjust—up and down—their pledges in light of what reviews actually reveal about what is working.

We see that volunteering activity as essential because formal intergovernmental agreement on review procedures seems highly unlikely given the large number of countries with diverging interests involved in Paris. Smaller clubs of countries that agree to mutual review could be very helpful, as with the U.S. and China, who agreed to submit themselves to mutual peer review of their efforts to remove fossil fuel subsidies under the G-20.[51] This kind of review is particularly important because it is less focused on the specific compliance question of whether countries met their targets and more concerned with the policie that were tried, what worked, and what didn't.[52]

National governments and other jurisdictions that have an incentive to make the Paris framework effective have a strong incentive to volunteer for this treatment. Traditionally, these questions have been discussed and debated by national governments. Broadly, under Paris, a new framework is emerging that encourages sub-national governments and other entities to make pledges—more than 12,500 such pledges now exist, and the number is growing.[53] The sub-national actors most keen to make this new process work should work harder to establish accountability and learning mechanisms, which will help to establish which of these pledges actually matter and what the rest of the world can learn from them.[54]

Over time, technology can help. New technologies for remote sensing and measurement can allow civil society actors to contribute substantially to monitoring compliance with Paris goals. New satellites are being flown that can measure CO_2 (and some other gases) remotely.[55] A very large network of existing ground stations, mainly in the Northern Hemisphere, makes it possible to de-convolute data on concentrations of gases in the atmosphere into likely emissions, with resolution at the level of some countries. As in arms control, it is likely that a few countries will invest in these technologies that will become the backbone of a more sophisticated system for determining what countries are actually doing and the impact on emissions.

Unlike in arms control, where verification tends to be dominated by the national technical means of governments and international organizations, civil society is poised to play a central role in building useful information systems. Already, the most systematic and reliable data on national policies and emission trends is being compiled by NGOs.[56] Scientists also have the capacity to apply methods—such as from energy system modeling and atmospheric monitoring—to spot trends in national and regional behavior and compare them with policy pledges.[57] As civil society gets more organized and strategic in its efforts to influence climate policy, this is a niche where its efforts may be most visible and effective.

Conclusion

For some analysts, international cooperation is important in its own right—it is part of a new notion of sovereignty in which nations embed themselves in international institutions. By this logic, multilateralism is nearly always an unalloyed good and unilateralism or more discriminatory forums are the opposite. The logic of global public goods points in a similar direction—some problems and opportunities are truly global and require global approaches.

While there are merits to intrinsic globalism and governance, in this paper we have taken a more hard-nosed approach. The purpose of cooperation, principally, is to solve problems that require collective governance. Success requires focusing on the places that have leverage. For climate change—because it is centrally about the transformation of energy systems that span every economy—that leverage does not come from central authorities with weak leverage over the economics and politics of energy.

The process we have outlined here emphasizes the central role for facts on the ground, which emerge from niches where there is stronger motivation and willingness to invest in change. New ideas and technologies then spread, creating still more facts on the ground and catalyzing new political coalitions that favor (or do not oppose so vehemently) more ambitious action.

Today, the world is very early in that process, and for most countries, policy efforts are driven by concerns other than climate change and often remain tentative. The landscape for ambitious cooperation is mostly a set of niches, networked by fairways that span the globe. California, Austin, the Vatican, and Shanghai have more in common than the other jurisdictions that are more geographically proximate. But with new facts and new political support, the fairways will widen while the niches deepen. But the world is still in the early stages of that major political transformation.

To be sure, climate change is a global problem whose solutions, ultimately, will require global cooperation. It is hard to see all of the world's economies cutting emissions nearly to zero—incurring potentially large costs—unless governments have confidence that their economic competitors are adopting comparable measures.[58] Aiming for that goal, however, requires confidence in the steps to get there. Without confidence in new technologies and the policy and investment support that follows from that confidence, even the most advanced and elaborated global diplomatic agreements can only produce an ever-wider chasm between stated goals and realistically achievable outcomes.

To highlight the relative importance of facts on the ground over diplomacy, it is an interesting thought experiment to imagine what would have happened to climate politics had Hillary Clinton won the 2016 presidential election. Indeed, we wrote the first draft of this paper in fall 2016 with that outcome in mind. At the time, what we saw that concerned us was an excessive enthusiasm for diplomacy when, in reality, it is the alteration of energy technologies, markets, and behavior that really matter. Continuous advances in the Paris agreement are all well and good, but not if they serve simply to open up an ever-wider gap between aspirational goals and implementable realities.

Today, the risk is the opposite: that anger against President Trump's Paris decision will drive too much emphasis on rescuing or propping up diplomacy after the Trump assault. The underlying realities—whether Clinton or Trump—barely change. It's the facts on the ground that matter.

Acknowledgements

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Endnotes

1. This paper is first in a series from the Brookings Institution that will look at the underlying political, market, and technological forces that are affecting global energy markets, and, therefore, also the emissions that harm the climate. The series aims to rewire the thinking about climate change to concentrate political realism and strategy around the transformation of energy systems, a topic that has been dominated thus far by technical engineering analysis.
2. David G. Victor, "Why Paris Worked: A Different Approach to Climate Diplomacy," *Yale Environment 360*, December 15, 2015, http://e360.yale.edu/features/why_paris_worked_a_different_approach_to_climate_diplomacy.
3. In following this logic we draw on Charles F. Sabel and David G. Victor, "Governing global problems under uncertainty: making bottom-up climate policy work," *Climatic Change* 144, no. 1 (2017): 15-27.
4. The messages here in this essay will resonate, in part, with many other scholars who have been thinking about how simultaneous decentralization and integration of the global economy affect governance. Some relevant early thinking here is from Inge Kaul, Isabelle Grunberg, and Marc Stern, eds., *Global Public Goods: International Cooperation in the 21st Century* (New York: Oxford University Press, 1999) in particular. See also Anne-Marie Slaughter, "The Networks of US governance," *Yale Books Unbound*, March 30, 2017, http://blog.yalebooks.com/2017/03/30/the-networks-of-u-s-governance/, and Thomas Hale, David Held, and Kevin Young, *Gridlock: Why Global Cooperation is Failing when We Need It Most* (Cambridge: Polity, 2013), and David G. Victor, *Global Warming Gridlock: Creating More Effective Strategies for Protecting the Planet* (Cambridge: Cambridge University Press, 2011), as well as the study by Thomas Wright, *All Measures Short of War: The Contest for the Twenty-First Century and the Future of American Power* (New Haven, CT: Yale University Press, 2017), which adds important issues related to the resurgence of geopolitics. Finally, there is substantial academic work looking at decentralized governance. See Elinor Ostrom, "A General Framework for Analyzing Sustainability of Social-Ecological Systems," *Science* 325, no. 5939 (July 24, 2009): 419-422, http://science.sciencemag.org/content/325/5939/419.full and Robert O. Keohane and David G. Victor, "The Regime Complex for Climate Change," (Cambridge, MA: Harvard Project on International Climate Agreements, January 2010) as well as Thomas Hale and David Held, *Beyond Gridlock* (Cambridge: Polity, 2017) and Jessica F. Green, "Transnational delegation in global environmental governance: When do non-state actors govern?" *Regulation and Governance*, February 27, 2017, http://onlinelibrary.wiley.com/doi/10.1111/rego.12141/abstract.
5. See "Federal Energy Management Program," U.S. Department of Energy, https://www.energy.gov/eere/femp/federal-energy-management-program.
6. A paper by Howard Gruenspecht on the future of U.S. coal consumption, to be published in this series, will look at those market pressures in more detail. There is perhaps no place where underlying commercial pressures on fuel choices are more consequential for emissions—and where the federal government has less leverage than widely thought—than the future of coal.
7. David G. Victor, Keigo Akimoto, Kaya Yoichi, Mitsutsune Yamaguchi, Danny Cullenward, and Cameron Hepburn, "Prove Paris Was More than Paper Promises," *Nature* 548 (August 1, 2017): 25-27, https://www.nature.com/news/prove-paris-was-more-than-paper-promises-1.22378.
8. Two papers by Rahul Tongia, of Brookings India, in our series will examine the underlying forces affecting consumption of coal in India and the rise of renewables—and how those shape India's engagement with global climate diplomacy.
9. On sources of emissions, see generally Intergovernmental Panel on Climate Change (IPCC), "Climate Change 2014: Mitigation of Climate Change: Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change," (Cambridge: Cambridge University Press, 2014), http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf, notably figure SPM.1. Here we focus on the high-level numbers but are mindful of large uncertainties, especially in land use-related emissions. A small fraction of the industrial CO_2 emissions come from production of cement, but the vast majority are from the energy system.
10. IPCC, "Climate Change 2013: The Physical Science Basis: Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change," (Cambridge: Cambridge University Press, 2013), http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf.
11. National Research Council, Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration (Washington, DC: The National Academies Press, 2015).
12. An early paper in our series, by Amar Bhattacharya, will examine the challenge of trying to build climate policy into large-scale infrastructure spending driven by the G-20's efforts to boost global economic growth.
13. A paper in this series by Eirik Wærness, chief econ-

omist at Statoil, will look at how that firm and the industry are contemplating massive transformation in the expectations and operations of the oil and gas industry.

14. See The Oil and Gas Climate Initiative (OGCI), a consortium led by the CEOs of 10 major firms that account for one-fifth of global oil and gas production, and focused on investments in carbon capture utilization and storage (CCUS) and managing methane emissions.
15. See David G. Victor, David R. Hults, and Mark Thurber, *Oil and Governance: State-Owned Enterprises and the World Energy Supply* (Cambridge: Cambridge University Press, 2012); and Bernard Mommer, *Global Oil and the Nation State* (Oxford: Oxford University Press, 2002).
16. For example, see Arnulf Grübler, Nebojša Nakićenović, and David G. Victor, "Dynamics of Energy Technologies and Global Change," *Energy Policy* 27, no. 5 (1999): 247-80, http://www.sciencedirect.com/science/article/pii/S0301421598000676.
17. See, notably, the analysis in Staffan Jacobsson and Volkmar Lauber, "The politics and policy of energy system transformation—explaining the German diffusion of renewable energy technology," *Energy Policy* 34, no. 3 (2006): 256-76, https://www.sciencedirect.com/science/article/pii/S0301421504002393, which shows how the early political coalitions favoring solar power in Germany were small and weak, but as the technology scaled, it shifted to a much broader base, including labor that sought high-paying jobs in producing solar cells. (Eventually the entire German solar production industry collapsed as the technology scaled further—taking advantage of even cheaper Chinese manufacturing.)
18. Michael Burger and Justin Gundlach, "The Status of Climate Change Litigation: A Global Review," (Nairobi: U.N. Environment Programme, May 2017), http://columbiaclimatelaw.com/files/2017/05/Burger-Gundlach-2017-05-UN-Envt-CC-Litigation.pdf.
19. See, for example, Joseph El Aldy, William Pizer, Massimo Tavoni, Lara Aleluia Reis, Keigo Akimoto, Geoffrey Blanford, Carlo Carraro, et al, "Economic Tools to Promote Transparency and Comparability in the Paris Agreement," *Nature Climate Change* 6, (August 2016).
20. China, most notably, has pledged to stop growth in CO_2 emissions by 2030 and will probably beat that goal by five to seven years. It has invested massively in making its coal-burning fleet of power plants more efficient and in diversifying somewhat away from coal—all in an effort to reduce local air pollution and cut costs. These so-called "co-benefits" approaches to climate policy do not deliver deep decarbonization, but they do reinforce shallow decarbonization and can help create (or at least sustain) interest groups that will, in time, favor going deeper. See also Qi Ye, "China's post-coal growth," *Nature Geoscience* 9, (2016): 564-66, doi:10.1038/ngeo2777. A similar logic is playing out in India as well, where bold targets for pursuing renewable power look to Western observers like a firm commitment to address global climate change, but in reality are rooted in more powerful local goals, such as electrification, job creation, and management of local pollution. On this, see Rahul Tongia, "How India Can Meet its Ambitious Renewable Energy Targets," *The Wire*, December 2016, https://thewire.in/89204/renewable-energy-targets-heres-how/.
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23. Calculation based on "Emission Database for Global Atmospheric Research (EDGAR), release

EDGARv4.3.2," European Commission Joint Research Centre, 2017, http://edgar.jrc.ec.europa.eu, and computed for all greenhouse gas emissions. The 11 core European nations are (in descending order of emissions in 2015): Germany, the United Kingdom, France, Belgium, Netherlands, Sweden, Denmark, Austria, Finland, Switzerland, and Norway. We are mindful that different observers will put different countries on that list and might include Italy and Spain, for example, but the main empirical point we are making would not change.

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49. The "handled well" caveat is important since merely shifting to electricity for automobiles does not automatically lower emissions. See, for example, the cautionary study about electric vehicles in Atlanta, where marginal power supplies tend to have high emission factors in Stephen Holland, Nicholas Muller, and Andrew Yates, "Distributional Effects of Air Pollution from Electric Vehicle Adoption," *Journal of the Association of Environmental and Resource Economists*, (forthcoming). In most settings, adding renewable power to grids, which can be facilitated by batteries, lowers emissions, but a lot depends on which power generators are on the margin. In some settings, adding battery storage can increase emissions just as

adding more renewables can have similar or ambiguous effects. See for example Kyle Siler-Evans, Inês Lima Azevedo, and M. Granger Morgan, "Marginal emissions factors for the US electricity system," *Environmental Science & Technology* 46, no. 9 (2012): 4742-48, http://pubs.acs.org/doi/abs/10.1021/es300145v. Work on decentralization of power grids comes to similar conclusions. See, for example, Ryan Hanna, Mohamed Ghonima, Jan Kleissl, George Tynan, and David G. Victor, "Evaluating business models for microgrids: Interactions of technology and policy," *Energy Policy* 103, (April 2017): 47-61, http://www.sciencedirect.com/science/article/pii/S0301421517300101. A general conclusion of this literature is that decentralization of the power grid and a shift to renewables with storage does not automatically reduce emissions unless explicit incentives—for example, carbon pricing—are implemented.

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57. See Glen P. Peters, Corinne Le Quéré, Robbie M. Andrew, Josep G. Canadell, Pierre Friedlingstein, Tatiana Ilyina, Robert B. Jackson, Fortunat Joos, Jan Ivar Korsbakken, Galen A. McKinley, Stephen Sitch, and Pieter Tans, "Towards real-time verification of CO_2 emissions," *Nature Climate Change* 7, (November 2017): 848-50, https://www.nature.com/articles/s41558-017-0013-9; David G. Victor, Keigo Akimoto, Kaya Yoichi, Mitsutsune Yamaguchi, Danny Cullenward, and Cameron Hepburn, "Prove Paris Was More than Paper Promises," *Nature* 548 (August 1, 2017): 25-27, https://www.nature.com/news/prove-paris-was-more-than-paper-promises-1.22378; and Joseph El Aldy, William Pizer, Massimo Tavoni, Lara Aleluia Reis, Keigo Akimoto, Geoffrey Blanford, Carlo Carraro, et al., "Economic Tools to Promote Transparency and Comparability in the Paris Agreement," *Nature Climate Change* 6, (August 2016).
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The danger in deregulation

Samantha Gross

In the last few days, the Trump administration's oil and gas deregulation push entered a frantic new phase. On the last business day of 2017, the Department of the Interior rescinded a 2015 rule regulating hydraulic fracturing (or fracking) on public lands, and reworked regulations on safety for offshore drilling. Another dramatic announcement occurred on January 4, when the administration proposed opening up nearly all U.S. offshore waters to drilling.

President Trump has been clear about two goals of his administration: a push for what he calls "energy dominance" and a clear distaste for regulation of all kinds, particularly of the energy industry. But these two goals can be contradictory—the ongoing regulatory rollback may not ultimately benefit the energy industry. Deregulation could even do more harm than good, creating an uncertain long-term policy environment and undermining public trust.

Changing policy creates business risks

As I've written earlier, the energy industry invests primarily in capital-intensive, long-lived assets—oil fields or power plants with lives measured in decades. A stable policy environment is important to these investments. Regulations and policy that are created in one administration can be rolled back in another, and the instability creates a challenge for managing and valuing such assets. Energy companies crave regulatory certainty.

Energy companies crave regulatory certainty.

Many companies, particularly large international corporations, are unlikely to substantially change their practices in response to the regulatory rollback, as they have global operating procedures to prevent safety and environmental incidents that could harm their assets or reputation. But when an incident occurs, the entire industry bears the reputation of its weakest actor. A regulatory floor to govern behavior is thus good for everyone.

Reputation and trust are the most important assets of all

In the United States and around the world, energy production depends on support from local communities, what the industry calls "social license to operate." Especially in a democracy, public opposition can make life very difficult for energy producers. Public support for energy resource development depends on trust—in the companies doing the development and in the regulatory structure that governs their activities.

When the Trump administration dismantles energy regulation, it runs the risk of undermining the trust that underpins domestic energy development. U.S. oil and gas production has grown dramatically in recent years, but we have also seen a public backlash.

For example, hydraulic fracturing, and the oil and gas development that depends on it, faces deep grass-roots opposition in many parts of the country. Concerns about contamination of drinking water and other water resources are the most pressing concerns. Three states have banned the practice entirely, including New York and Maryland, which border the Marcellus Shale gas resource (the third is Vermont, which has no known oil or gas resources). The hydraulic fracturing regulations the Trump administration withdrew were focused on well construction, wastewater management, and chemical use disclosure—the issues of greatest concern to the public.

Likewise, the Deepwater Horizon disaster in 2010 was a crucial moment for the oil and gas industry in the United States. A cascade of failures resulted in the largest oil spill in U.S. history. A bipartisan presidential commission studied the incident, and the new regulations issued in response were an important step toward restoring trust in the U.S. offshore oil industry. But the Trump administration is altering these regulations, for example by eliminating independent inspections of safety and pollution equipment that the bipartisan commission recommended.

I don't mean to imply that oil and gas production in the United States is suddenly unregulated. State, local, and tribal regulations still apply to hydraulic fracturing on public lands. Safety and environmental regulations on offshore drilling have not been eliminated, just softened. And the proposal to open nearly all U.S. offshore waters to drilling is an opening salvo in a battle likely to go on for some time. Many governors, even Republicans, are vehemently opposed to drilling in waters off their states.

But the hard push toward deregulation is likely to have consequences for public trust, not just in companies, but in government itself. If the public feels that the government is being run by and for the energy industry, accomplishing many important societal goals—like modernizing infrastructure and preventing the worst impacts of climate change—become much more difficult.

The hard push toward deregulation is likely to have consequences for public trust.

Even in areas where oil and gas are central to the economy, the public favors protective regulation. Oklahoma provides an example. Seismic activity, caused by underground disposal of oil and gas wastewater, increased exponentially during the drilling boom there. The state government has responded with much greater regulation of underground waste disposal, including shutting down disposal wells in problematic areas, greatly increasing monitoring requirements, and establishing a public process for approving some disposal wells. Despite the increased regulation, the industry is thriving in Oklahoma, which was the sixth largest oil-producing and third largest gas-producing state in the United States in 2016.

Oil and gas production involves a delicate balance between sufficient regulation to protect health, safety, and the environment and ensure public trust, without unnecessarily strangling development. Smart people across the political spectrum are likely to disagree on the particulars of a "Goldilocks" regulatory scheme. But I fear that this administration is moving too far and too fast in the direction of deregulation, potentially harming the industry it is trying so hard to protect and promote.

China's coal consumption has peaked

Ye Qi and Jiaqi Lu

China's coal consumption has steadily decreased by a few percentage points a year since 2013, prompting our pronouncement of a coal consumption peak in an article published in the summer of 2016 in *Nature Geoscience*.

This declaration was echoed quickly by Zhang Guobao, former minister of the National Energy Administration, who went further to suggest that the government make an official announcement on the coal peak.

However, in 2017, the beast of coal seemed to be quite untamed. Coal prices rose sharply, production and consumption went up, and the coal inventory was in sharp decline. Coal consumption appears to have made a quick rebound.

In a recent report by the Global Carbon Project published during COP 23—the informal name for the 23rd Conference of the Parties to the United Nations Framework Convention on Climate Change—the authors predicted a 3 percent increase of coal consumption in China, leading to a 3.5 percent increase in China's carbon emissions, a key contributor to a 2 percent increase of global emissions in 2017.

Many are concerned about the robustness of China's energy decarbonization and its implication for climate change. Has China's coal consumption really peaked?

First of all, the 3 percent increase of China's coal consumption was likely to be an overestimate. The estimation was based on data from the China Coal Industry Association and the National Energy Administration for the first half of 2017, when China's coal consumption experienced a sharp rebound. The CCIA reported 5 percent growth, while the NEA said it was 1 percent, with a difference of 100 million metric tons between the two.

The Global Carbon Project report seems to have taken a simple arithmetic average of the two data sources. This treatment is inconsistent with convention for inter-annual comparison. The CCIA data is not used in official data reporting, since it includes only larger coal producers, which respond quite differently from smaller ones. In addition, its treatment of inventory is quite different from national coal statistics. In 2016, the CCIA calculated the inventory decrease to be about 240 million tons, causing 2 percent greater than the official data on total consumption. Thus, the CCIA data can be quite informative in understanding coal production of large producers, but not the best source to cite for approximating coal consumption, especially for inter-annual comparison.

The NEA data tends to be consistent with the official release from the National Bureau of Statistics and thus more appropriate for inter-annual comparison. According to the NEA, in the first three quarters of 2017, coal consumption in China reached 2.81 billion metric tons, an increase of less than 1 percent from 2016. A similar estimation of 2.82 billion to 2.83 billion tons is corroborated by the Energy Research Institute of the NDRC.

We support the conclusion that coal consumption is likely to have experienced a rebound of around 1 percent in 2017. Total consumption would be 3.82 billion metric tons—150 million tons less than that of 2015, or 420 million tons less than the 2013 level. Even if coal consumption increased by 3 percent to 3.90 billion tons in 2017 as the Global Carbon Project report said, it is still far less than the 4 billion tons in 2015, let alone challenging the 4.24 billion tons peak in 2013.

Given the inappropriate use of the data sources, the Global Carbon Project estimation of global emissions and contribution from China, especially from its coal consumption, may be misleading. Using the GCP estimation approach, we calculate that China's overall emissions increase in 2017 would be closer to 1 percent, instead of 3.5 percent—still lower than the 2014 level.

Countering the market effect of rebounding coal use in power and industry, the government has been implementing strong policies to substitute natural gas and electricity for coal use, mainly to address the air pollution problem. As a result, gas consumption increased by 17 percent in the first 10 months of the year. It is estimated that the substitution effort would replace about 47 million metric tons of coal use in 2017.

Entering the last quarter of the year, the momentum of coal use growth faded. In September, coal-fired electricity output and steel production, together representing about 75 percent of overall coal consumption, declined by 0.5 percent and 1.4 percent, respectively, and further dropped by 2.8 percent and 1.3 percent in October. In November, coal-fired power production continued to decrease by 1.4 percent from last year.

Looking ahead, we do not anticipate significant new growth of coal consumption this year or in the next few years. First of all, the Chinese government is not setting a higher target of growth for 2018. The traditional drivers of coal growth—construction and manufacturing—will continue to give way to the service sector in economic growth. Real estate development is experiencing the coldest winter ever due to restrictive regulations by the central and local governments. Anticipation of a property tax would make speculators switch from "buy" to "sell" mode.

We stick to our conclusion made in 2016: Coal-fired growth is over, despite the fact that coal remains the primary fuel for the Chinese economy.

Additionally, investment in infrastructure construction by local governments is now haunted by the local debts and is unlikely to grow quickly. In fact, some provincial governments have gone public to acknowledge and correct their overestimations of GDP and revenue. We stick to our conclusion made in 2016: Coal-fired growth is over, despite the fact that coal remains the primary fuel for the Chinese economy.

In addition, the regional coal-cap policy will continue to squeeze coal out of the energy mix, especially in the haze-intensive regions in the north. It is expected that even less coal will be used next winter, when more gas pipes are in place for heating.

The real game changer is clean energy. The price of solar photovoltaic is at an all-time low, enough to compete against coal for power generation. Additionally, wind power is well positioned to play an even bigger role.

Nevertheless, China is still the single largest coal user in the world, and coal represents more than 60 percent of its energy mix. But in the long run, coal consumption will continue declining—with current policies and the structural transformation of the economy from being a heavy industry-led, export-driven model to one sustained by services and domestic consumption—despite the annual and seasonal fluctuations.

We have no doubt that China's coal consumption has peaked and coal-fired economic growth has come to an end.

Nobody knew border carbon adjustments could be so complicated

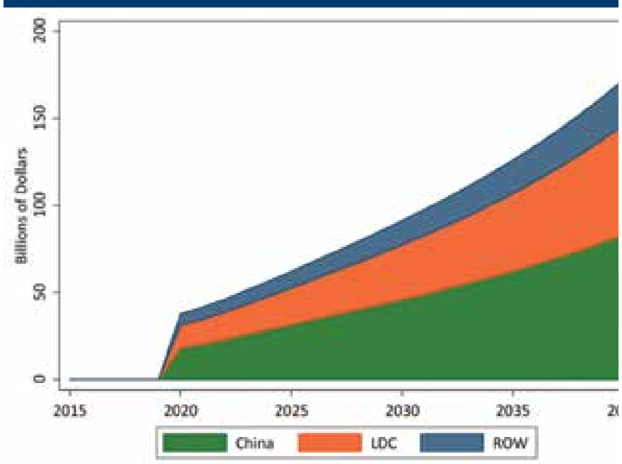
Warwick J. McKibbin, Adele Morris, Peter J. Wilcoxen and Weifeng Liu

Two important design choices for a U.S. carbon tax policy are the use of the revenue and whether and how to include measures to address the competitiveness concerns of American businesses. Both of these policy design choices affect the political appeal and overall performance of the policy, and their effects can be interdependent. For example, a carbon tax that funds reductions in corporate income tax rates could make U.S. firms more competitive overall than they otherwise might have been.

In "The role of border carbon adjustments in a U.S. carbon tax," Warwick McKibbin, Adele Morris, Peter Wilcoxen, and Weifeng Liu examine carbon tax design options in the United States using a model of the global economy. Through four policy scenarios the authors explore two overarching issues: (1) the effects of a carbon tax under alternative assumptions about the use of the resulting revenue, and (2) the effects of a system of import charges on carbon-intensive goods ("border carbon adjustments").

Consistent with earlier studies, the authors find that the carbon tax raises considerable revenue and reduces CO_2 emissions significantly. Gross annual revenue from the carbon tax with lump sum rebating and no BCA begins at $110 billion in 2020 and rises gradually to $170 billion in 2040. By 2040, annual CO2 emissions fall from 5.5 billion metric tons (BMT) under the baseline to 2.4 BMT, a decline of 3.1 BMT, or 57 percent. Cumulative emissions over 2020 to 2040 fall by 48 BMT.

Figure 1. Border carbon revenue by region of origin



Also consistent with earlier studies, the paper finds that the carbon tax has very small overall impacts on GDP, wages, employment, and consumption. Different uses of the revenue from the carbon tax result in slightly different levels and compositions of GDP across consumption, investment and net exports. Overall, using carbon tax revenue to reduce the capital income tax rate results in better macroeconomic outcomes than using the revenue for lump sum transfers. In a finding new to the literature, our results show that border carbon adjustments (BCAs) can have strikingly different effects depending on the use of the revenue and actually do more harm than good, depending on how the revenue is used.

In sum, a carefully designed carbon tax in the United States can reduce emissions significantly with minimal effect on the economy. McKibbin et al. find no evidence of meaningful emissions leakage abroad, even when the U.S. policy is unilateral. Using carbon tax and BCA revenue to reduce distortionary taxes produces better economic outcomes overall and for most individual sectors. To the extent that policymakers wish to protect the interests of energy-intensive trade-exposed industries with BCAs on imports, they should endeavor to tailor the adjustments to narrow, particularly vulnerable, subsectors so as not to inadvertently appreciate the U.S. dollar and do more harm than good overall.

Is the United States the new Saudi Arabia?

Samantha Gross

In its January Oil Market Report, the International Energy Agency (IEA) predicts "explosive" growth in U.S. oil production, in reaction to rising oil prices. In a recent congressional hearing, Fatih Birol, Executive Director of the IEA, described the United States as "the undisputed oil and gas leader in the world over the next several decades." U.S. production is forecast to exceed 10 million barrels per day in 2018, surpassing Saudi Arabia and behind only Russia.

This incredible surge in production begs the question—is the United States taking on Saudi Arabia's role in the oil market? It's an interesting question, and certainly one that the current administration raises with its emphasis on "energy dominance." But the answer is no—the U.S. industry will never play a similar role to Saudi Arabia's in the oil market, no matter how much U.S. oil production grows. To understand why, it's helpful to consider recent oil market events.

OPEC pulls back supply to boost prices, but to what end?

After oil prices reached more than $110 per barrel in 2014, the benchmark Brent crude oil price collapsed to as little as $30 per barrel in early 2016. In response, OPEC combined with Russia to decrease oil production, with the goals of increasing oil prices and decreasing oil inventories. The deal to reduce production by 1.8 million barrels per day (bbl/d) was struck in late November 2016 and has since been extended through the end of 2018. The Saudis have delivered the largest portion of the supply decrease, significantly exceeding their agreed-upon cut of 486,000 bbl/d. Since the production cuts, the oil price has risen by roughly $25 per barrel.

This result certainly looks like a success for OPEC. But given changes in the global oil market, OPEC's overall gains are likely to be temporary.

The shale oil that dominates U.S. production growth delivers oil faster with much lower up-front costs than traditional oil and gas. This allows U.S. production to be very responsive to price swings like the one that OPEC has created in the last year. (I described this in an earlier post.) This responsive U.S. production is rapidly counteracting the OPEC production cut. In fact, the IEA forecasts that increasing U.S. oil production alone will nearly make up for the OPEC cut by the end of 2018.

The rapid increase in U.S. oil production leaves OPEC in a difficult position. OPEC has shown its ability to compel production cuts from its members and raise the oil price, but at the cost of losing market share as U.S. production has grown in response to higher prices.

This loss of market share may be even more harmful to OPEC in today's world of energy abundance. Predicting the timing of peak oil demand is becoming a parlor game among oil economists. While nearly all agree that the world will see one to two decades of continuing oil demand growth, maintaining market share in this changing world is more important than in the past. OPEC may have won the battle to raise the oil price, but it appears to be losing the market share war.

The United States is a crucial oil producer, but not a "dominant" one

The United States has become an important oil producer and changed the landscape of the global oil market, particularly with its ability to more quickly rebalance the market in response to price changes. But important differences between the U.S. and Saudi oil industries mean that the United States will not take over the Saudi role in global oil markets, even though it is poised to surpass Saudi Arabia in terms of production volume.

Saudi oil is all produced by a single entity—Saudi Aramco—which is owned and operated by the Saudi government. Saudi Aramco does not operate on a simple profit motive like a for-profit company. Concerns about politics and management of the global oil market influence production decisions in a way that would not occur at a company solely focused on profit. Saudi Aramco plans to sell shares equaling five percent of its value in an initial public offering (IPO) in the second half of this year, but the fundamental structure and decisionmaking at the company will remain controlled by the government.

In the United States, the oil industry is made up of dozens of companies that make individual investment and production decisions, based on their own costs, financial positions, and appetites for risk. The U.S. oil industry will never act as one to manage the market or raise prices. In fact, such behavior is illegal under anti-trust law. But this is exactly how Saudi Aramco and the other OPEC members operate—it is the very purpose of OPEC.

A related point is that all of the individual U.S. producers are price takers in the marketplace, meaning that they have no ability to influence global oil prices through their own actions. But Saudi Aramco is large enough for its production decisions to influence prices. In addition to reducing production to push prices upward, as is happening today, Saudi Arabia can rapidly increase production to deal with oil supply disruptions. Saudi Arabia is the only oil producing country with significant spare production capacity. The U.S. Energy Information Administration estimates that the Saudis keep 1.5 to 2 million bbl/d of production capacity in reserve, a strategy that would not make economic sense for a for-profit company.

This difference between price taking and price making is why describing the United States as "energy dominant" is misleading. To me, "dominance" implies an ability to move markets, whereas the U.S. industry, while strong and increasingly important to global energy security, is not structured to achieve that end.

Another important difference between Saudi oil production and that in the United States is the very low cost of producing Saudi oil. The actual costs are a close-kept secret, but we know that they are among the world's lowest. In a world where oil demand is likely to plateau and fall over the coming decades, the Saudi oil industry is likely to remain profitable through the end of the oil era. The U.S. oil industry has achieved declining production costs through relentless competition and the discipline of lower prices. But the shale oil resources that have fueled the U.S. production boom are inherently more expensive to produce than those in Saudi Arabia.

How will the Saudis play in the new oil world?

Although the United States has become an indispensable source of oil and gas production, Saudi Aramco will continue to play a unique role in global oil markets, owing to its immense size and influence and its low production costs.

An interesting question to watch over the coming years will be how Saudi Aramco reacts to the combination of abundant supply and an end to demand growth that, although it may be many years away, is inexorably approaching. To date, the Saudis have focused on managing prices and ensuring that their reserves last well into the future. But with a potential end to demand growth, will they change their strategy to compete more strongly in the market on price, acting more like the American producers? Only time will tell.

Patenting invention

Clean energy innovation trends and priorities for the Trump administration and Congress

Devashree Saha and Mark Muro

Energy innovation matters hugely to America's future. The reason: Energy innovation represents a gargantuan $1.4 trillion global business opportunity, with more up-side on the way.

The bottom line: Low-carbon technology holds great potential to spark high-quality growth in U.S. regions, support the manufacturing sector, and improve the trade balance.

And yet, there is a problem. At just the moment when the U.S. clean energy innovation enterprise may be hitting a flat spot, the Trump administration has proposed draconian federal budget cuts that raise new concerns about the future of the nation's commitment to low-carbon economic development.

Which is why—as Congress turns to shaping the 2018 budget—it is worth assessing the status of the U.S. cleantech innovation enterprise, both nationally and regionally, as it is unfolding across 14 technology areas and the nation's diverse metropolitan areas.

To that end, this first brief of two on cleantech innovation—a forthcoming analysis will examine venture capital (VC) dynamics—looks at technology patenting activity as a key indicator for monitoring the development of new technologies, as represented by the volume and topics of new patents resulting from public and private funded research.

What do these data show? Overall, the data show that even as cleantech patenting has grown over the years, serious concerns remain about the competitiveness of the U.S. cleantech innovation scene. At the same time, while much of America's patenting takes place in relatively few large metropolitan areas, significant cleantech innovation activity extends into all regions of the country. That breadth underscores both the relevance and potential of low carbon innovation.

Taken together, the findings of this brief provide a mixed picture of U.S. cleantech innovation that runs as follows:

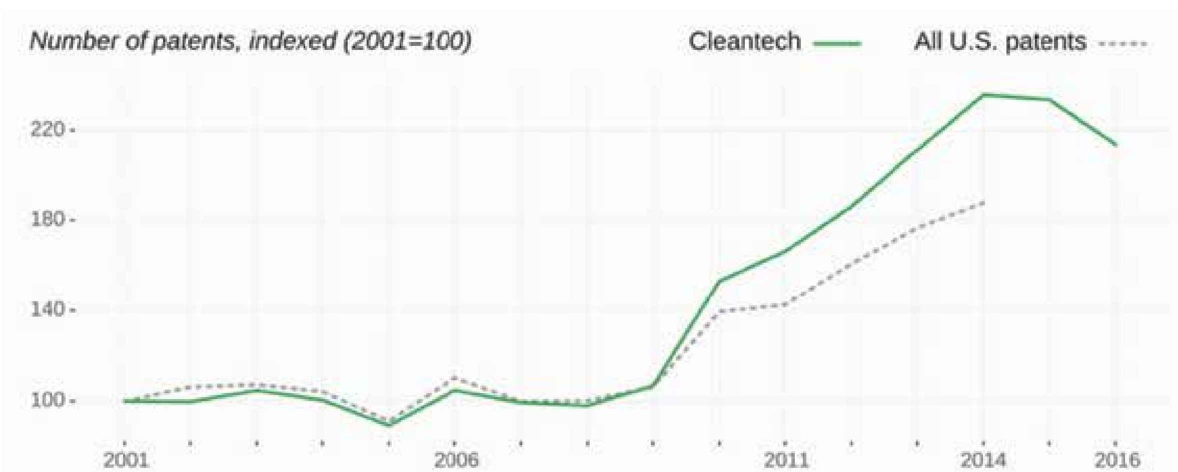
- **U.S. cleantech patenting has grown significantly since 2001, outpacing growth in all U.S. patents, but may now be flagging.** Since 2001, the total number of granted patents in the cleantech sector has more than doubled—from a little less than 15,000 cleantech patents granted in 2001 to approximately 32,000 in 2016. With that said, the number of cleantech patents granted in the country has declined by 9 percent between 2014 and 2016.

- **Cleantech patenting is concentrated in relatively few technology categories.** Overall, a total of 186,500 patents have been granted in the United States since 2011 across 14 cleantech categories. Of this activity, advanced green materials, energy efficiency, and transportation each accounted for fully 18 percent of the total patenting, while energy storage accounted for another 15 percent. In contrast, drastically fewer patents are being granted in other cleantech areas such as geothermal energy, hydro & marine power, and nuclear generation.

- **U.S. cleantech patenting is both concentrated in large metropolitan areas and widely distributed across diverse regions of the country.** Cleantech patenting, in terms of absolute patent issuance, is highly concentrated in a relatively small number of larger metropolitan areas. 10 metro areas ranging from **Boston** and **Detroit** to **Houston, Minneapolis, San Francisco,** and **San Jose** accounted for 38 percent of the cleantech patents developed by U.S. inventors since 2011, while 20 metro areas accounted for 52 percent. And yet, the patent data make clear that cleantech innovation is also widely distributed across diverse regions of the country—in red and blue states, and in big and small metros such as **Ann Arbor, Boise City, Columbus, IN, Greenville,** and **Knoxville**.

- **The nation's metro areas, both big and small, display distinctive profiles in cleantech patenting.** The nation's most inventive low-carbon

Figure 1. After years of growth the number of cleantech patents granted by TSPTO has declined since 2014



Source: Brookings analysis of IP Checkups' Cleantech PatentEdge database
Note: All U.S. patents data are only available through 2014

Figure 2. Which cleantech categories...

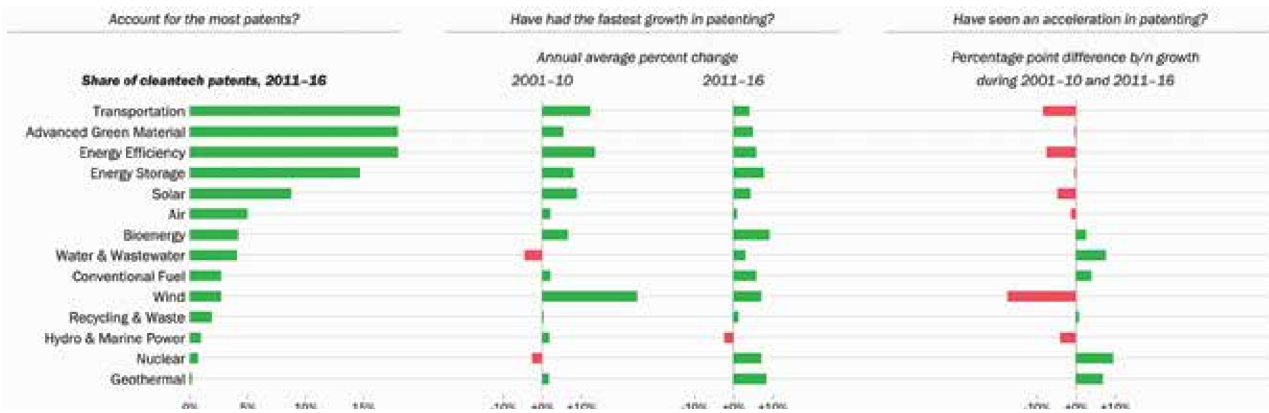
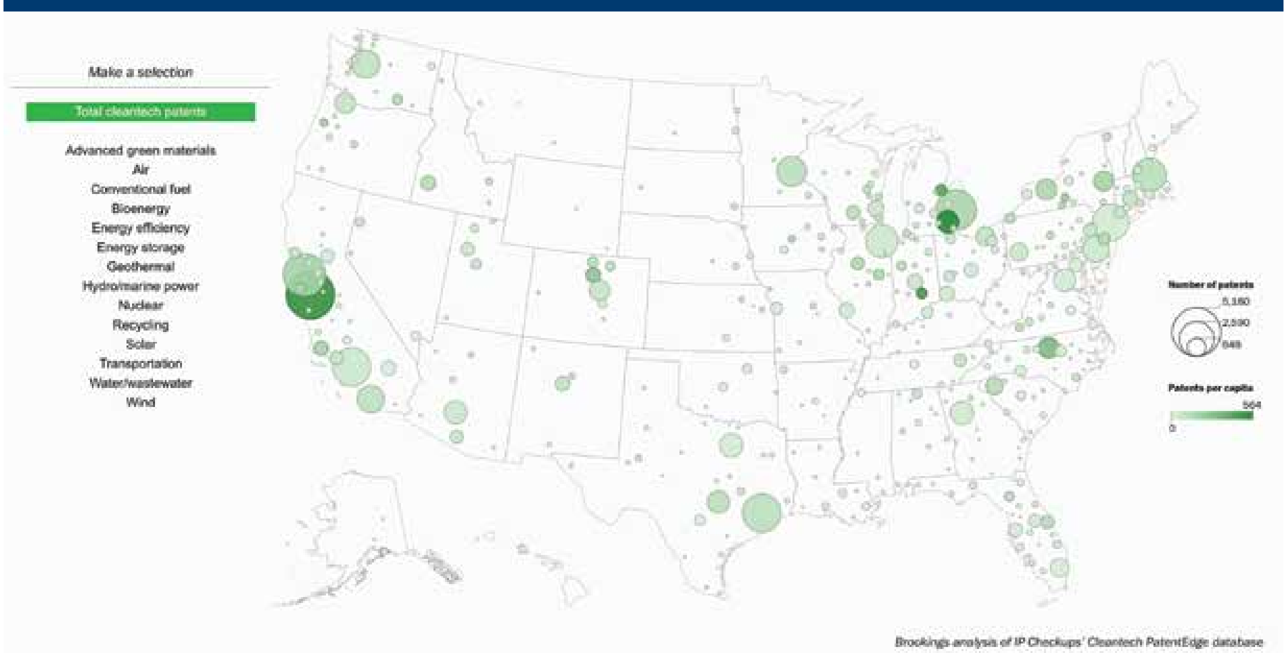


Figure 3. Total number of cleantech patents, 2011-2016



energy patenting metros vary in their specializations, meaning that varied regions with distinctive industry clusters are functioning as globally significant innovation hubs that convene local business, academia, and government to drive American competitiveness. Whether it is large metros such as **Detroit** specializing in transportation patents and **Houston** in conventional fuels, or smaller metros such as **Ames, IA** in bioenergy and **Wilmington, NC** in nuclear, a large number of America's metropolitan area stand out as regionally differentiated platforms for cleantech innovation.

- **The share of U.S. cleantech patents owned by foreign companies has grown over the years, raising concerns about the global competitiveness of U.S. companies.** In 2001, both U.S. and foreign-owned companies generated about 47 percent of cleantech patents each. By 2016,

> 51 percent of all cleantech patents were owned by large foreign multinationals, while only 39 percent were generated by U.S. companies. This trend reflects the globalization of cleantech industries, particularly in developed and developing Asian economies urgent about reducing carbon emissions and cornering growing markets for cleantech.

Given the size of the global clean energy economic opportunity, the United States can ill afford to relinquish its lead on innovation in the burgeoning global cleantech market to China or other countries. For that reason, Congress should set aside the skinny budget and draw on years of bipartisan support for energy innovation to coalesce around a core list of minimum viable supports for low-carbon innovation and growth. Most crucial will be provisions to **maintain clean energy R&D appropriations** at viable levels; **maximize the impact of the nation's 17 national energy laboratories**; and **preserve the Advanced Research Projects Agency (ARPA-E)** while **maintaining and scaling up the nation's energy innovation hubs and institutes**. For their part, states and regions can and must step up to **invest more robustly** on their own in low-carbon innovation, just as must the private sector, which must **argue more forcefully** for essential federal supports even as it moves to **shoulder more of the burden** itself.

In sum, Congress as well as the private sector and states and regions stand at a critical juncture this spring. With the economic potential of cleantech innovation widely acknowledged, the question has become: Will the U.S. compete?

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