Global Warming Gridlock

Global warming is one of today's greatest challenges. The science and economics of climate change leave few doubts that policies to cut emissions are overdue. Yet, after twenty years of international talks and treaties, the world is now in gridlock about how best to do this.

David Victor argues that such gridlock has arisen because international talks have drifted away from the reality of what countries are willing and able to implement at home. Most of the lessons that policy makers have drawn from the history of other international environmental problems to guide climate talks won't work on the problem of global warming. He argues that a radical rethinking is needed. This book provides a roadmap to a lower carbon future based on encouraging bottom-up initiatives at national, regional, and global levels, leveraging national self-interest rather than wishful thinking.

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Creating More Effective Strategies for Protecting the Planet

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Preface and acknowledgements: a journey studying international environmental regulation

Most of my professional life has focused, in one way or another, on the ways that humans affect the global environment. Greenhouse warming is the most complex and sprawling of those global problems; politically it is the toughest to solve. It has taken a career to understand the problem, and along the way I have accumulated many intellectual debts.

Before enrolling in graduate school at MIT in the late 1980s I worked with a research group at Harvard that studied atmospheric chemistry and physics. That group, led by Mike McElroy and Steve Wofsy, taught me more about basic science of the atmosphere and oceans than I ever learned as a student. At the time, the ozone layer was the big planetary worry, and through their eyes I learned how to read and interpret the cutting-edge science. I soon shifted my academic discipline to political science, but most of my career has been an attempt at serious interdisciplinary research on atmospheric and oceanic issues. That style of research only works when the scholar can read and interpret the frontier of research across often disparate disciplines. I trace my enthusiasm for interdisciplinary research to the orbit of interesting things I learned from Mike and Steve and the many other people in Cambridge, Massachusetts working on similar atmospheric problems. They included Jim Anderson's research group (which flew a converted spy plane into the ozone hole in the late 1980s and found the smoking gun showing that humans were to blame), Dick Holland, Ron Prinn, and Mario Molina. Today I spend very little time in that community, but read their journals and do my best to stay abreast. I worry that the community of political and legal experts – especially those who study environmental issues where the technical details matter – don't spend enough time immersed in the natural science. As will be evident in this book, most of the attributes of the global warming problem that make it politically such a hard

problem to solve trace back to the physical and biological characteristics of the chief pollutants.

When I arrived on campus to start my PhD, MIT assigned Professor Eugene Skolnikoff to be my advisor and fortuitously he had a similar interdisciplinary bent. I was part of the last cohort of MIT political science graduate students who studied science, technology, and international affairs. All of us were named David and we all had Gene as an adviser. As a graduate student I was an embarrassment to my department because I spent most of my time not with other political scientists but with chemists, physicists, oceanographers and especially engineers. Gene let me do that – he even encouraged such deviant behavior – and I am forever grateful. Jack Ruina, George Rathjens, and Carl Kaysen all encouraged such deviance. By luck, the few years centered on 1990 was the right time to be in Cambridge, Massachusetts. A dozen or so graduate students from all manner of disciplines – drawn mainly from MIT, Harvard, and Tufts – had a similar set of environmental interests. We set up a reading group, engaged faculty members, and did things. That orbit of folks included Thomas Bernauer, Beth DeSombre, David Festa, Tad Homer-Dixon, Tammi Gutner, David Keith, Marc Levy, Vicki Norberg-Bohm, Nancy Dickson, Ted Parson, Michael Molitor, and Peter Poole. We worked with faculty members such as Mike and Gene as well as Abram Chayes, Joe Nye, Bob Keohane, Bill Clark, Richard Cooper, Bob Frosch, Jay Fay, Lew Branscomb, Harvey Brooks, and Tom Schelling. When a field of research is taking shape geography really matters because most thinking and debating is done in person, and the early 1990s Cambridge was prime intellectual real estate.

I was unaware, at the time, just how much we all learned about politics from Bob Keohane. Bob, Peter Haas, and Marc Levy organized a series of studies on the "effectiveness" of environmental regimes. That is, do international regulatory systems, such as treaties, actually work? Their efforts shaped that field of study, and I soon found that most of my time as a political scientist focused on the question of effectiveness. That effort roped in Oran Young, then a professor at Dartmouth (now at Santa Barbara); Oran and Bob have blessed the study of environmental regimes with their insights. One of the things I have learned from them – perhaps to their horror – is that environmental research suffers because scholars care too much about their subject. An appreciation for the hard-nosed power politics needed,

for example, to protect the ozone layer or slow global warming is often lost in the evangelism around the need to halt planetary destruction. A high ratio of green evangelism to hard-nosed politics was on full display in 1992 during the Rio Earth Summit, an event that was pivotal for me because it helped me see the value in skepticism about international institutions. The world is full of promises that are not kept, and the study of international institutions is about understanding when those promises are credible and have an impact on behavior and when they are smoke. As we shall see in this book, many of the promises around global warming are still smoke twenty years later.

Other than meeting Gene and another very helpful MIT adviser, Ken Oye, I can't say I learned very much from graduate school that was useful. Geography was the chief asset. By luck, MIT was gearing up what, today, is the premier university research program on global climate change. Jake Jacoby, Ron Prinn, and Richard Eckaus led the effort, and I arrived on their radar screen by complaining that the Intergovernmental Panel on Climate Change (IPCC) scheme for converting greenhouse gases into common units was all wrong and should be scrapped. (Young students often supply indignancy in large quantities.) It turns out that was also one of the first problems that Jake and his colleagues studied, and we worked together. They have built an extraordinary research team – the Joint Program on Global Change Science and Policy – that stands as an example of what can be done with interdisciplinary research if you invest a decade or more in the effort. It is also a reminder that truly interdisciplinary research needs a common task – in their case, building and running an integrated model – so that people from different disciplines can all lend their skills in a focused way. Interdisciplinary research requires disciplinary gains lest scholars not find much reward for their academic careers. One of the reasons political science has had a hard time with interdisciplinary research is that our research does not easily lend itself to integrated tasks such as model-building and integrated models produce few disciplinary benefits for political scientists.

Three things happened in graduate school that changed my life. First, Gene and Abe Chayes created a research project on international diplomacy on global warming. We got funding from someone (in Cambridge, Massachusetts money is always pouring in for something) and had no idea what we were doing. But we knew it was important. So I started attending the climate talks, which had just

gotten under way, with the aim of keeping our endeavor informed of the latest events. (Young students usually have lots of time to do things that seem worthless but occasionally prove to be gold mines.) At the time – the very earliest days of what became the UN Framework Convention on Climate Change – climate diplomacy was such a backwater that NGOs were small in number and all of us were free to roam the negotiations. (That rule was quickly changed when one NGO – led by an American lawyer hired by OPEC – used free access to help block negotiations and became the de facto voice of the Kuwaiti government.) Milling around and watching the painstaking process in six languages taught me a lot about diplomacy and made me very skeptical that big UN talks would ever make much headway. John Maddox, editor of *Nature*, gave me six pages (a huge space, something I did not appreciate at the time) to explain my skepticism. I suggested that instead of big formal talks something different – smaller, more like the early years of the GATT, and focused on building complex package deals – should be tried. I still think that is right, and over the years I have learned a lot about why that approach to institutional design is better than many others. At the time, however, a dissenting view from a graduate student didn't have much impact. (Today that view still may have no impact.) The mania around global, legally binding global warming treaties was in full swing and hard to sway. Around the same time Gene wrote a piece in *Foreign Policy* explaining why the US policy process was prone to gridlock on global warming; that piece reads well still today, and hopefully he will see this book as a useful complement of insights on international gridlocks. I met a lot of people who were also present at the creation of the climate law, such as James Cameron and Philippe Sands (who had organized a coalition of low-lying island states and helped them become a truly effective voice), Dan Bodansky (who wrote an extraordinary diplomatic history of the talks), and Tony Brenton (who held the chair for the British government and came to Cambridge in 1992 for a sabbatical year, writing a wonderful book about environmental diplomacy called *The Greening of Machiavelli*). Richard Benedick, who had been the chief US negotiator on the ozone accords, helped all of us think about the right lessons from the history of environmental diplomacy. Jean Ripert was the senior French diplomat who led the climate talks and was always helpful; Michael Zammit Cutajar

soon led the climate secretariat and was a fountain of insight and discretion.

Abe, Gene, and I hosted meetings with the diplomats – culminating in sessions in Bermuda and Bellagio – that led to the idea of "prompt start." Once the talks leading to a climate treaty in 1992 were done, technically nothing more could happen on the diplomatic front until the treaty entered into force. "Prompt start" offered a way to keep the momentum so that useful efforts, such as building the procedures for reporting data, could get under way immediately. Abe, Gene, and I developed the idea; Ken Prewitt, head of the Rockefeller Foundation, helped us strip away the ideas that were distractions and focus on prompt start in particular; and the climate diplomats who participated in our meetings helped make it practically relevant. That idea turned out to be quite influential, and from the effort I learned a lot about how to organize meetings and get things done diplomatically. Lesson 1 was that offering locales like Bermuda and Bellagio would help. Lesson 2 was to keep it small. Lesson 3 was to treat the participants well. Academics forget that much of life is about getting the right people in the room and treating them with grace and respect; I was honored to learn that lesson at an early age from masters at the art.

Second, with help from Gene and Bill Clark, I spent my first summer of graduate school in Austria at the International Institute for Applied Systems Analysis (IIASA). Originally I was assigned the task of working with a group that studied acid rain to find ways to use computer models to make the negotiations on acid rain in Europe more effective. That was a good idea, but there wasn't much a graduate student could do on that front because the key questions hinged on politics rather than geeks doing research. So I wandered to a different part of IIASA's castle and met Nebojša Nakićenović and Arnulf Grübler. By the end of my first day I moved my office and started working with them on the question of why and how technology diffuses. They had put me on the task of modeling the diffusion of liquid hydrogen-powered aircraft and natural gas vehicles – two darling technologies of the day that might, one day, take a large share of the market. (Today, hydrogen aircraft are dead but natural gas vehicles have once again become the darlings of technologists who want to solve problems like dependence on oil and high emissions of warming gases.) The question was how large a share? And if those technologies

diffused, what would be the impact on things that people care about, such as emissions of warming gases or consumption of oil? I built some models that could answer those questions, wrote some scientific papers on the questions, and started a career with a foot firmly in the study of technological change. It is hard to over-estimate the importance of what I have learned working with Naki and Arnulf and the people in their orbit – among them, Hans Holger Rogner, Robert Pry, and the dean of their world view, Cesare Marchetti. Through that community I met Jesse Ausubel and worked with him for a summer as part of the Carnegie Commission on Science, Technology and Government. From Jesse I learned how to write, and since writing is about thinking and logic in reality I learned a whole way of thinking from him. For most students, graduate school is a time to get narrow and to lose useful communication skills. With Jesse's helping hand my experience was pretty much the opposite, and for that I am eternally grateful. Jesse also sent me to the National Center for Atmospheric Research (NCAR) for a summer to work on my thesis; there I met Mickey Glantz, Will Kellogg, and Steve Schneider. NCAR's Mesa lab is a great place to visit since it is the epicenter of so much research on climate change and it is physically stunning. I spent the summer reading about verification of international agreements; Jesse and I wrote a big review essay on the topic and that area has since become a large part of my research. Over the years he has included me on interesting projects – among them a meeting at the Scripps Institute of Oceanography at UC San Diego where I met Roger Revelle, Bill Nierenberg, Wally Broecker, Gordon MacDonald, Ram Ramanathan, and Dave Keeling for one of the early discussions of geoengineering and whatever else Roger and Bill had on their minds. The importance of that meeting didn't fully settle into my brain until I moved back to UCSD as a faculty member almost two decades later. I think it was through that meeting that I met Bill Nordhaus who is the dean of climate change economics; much of what the world thinks about climate economics goes back to his pioneering efforts and I have learned a lot from him over the years. Notably, from Bill and Dick Cooper I have more fully appreciated the use of emission taxes as a way to address global warming; they are among the few who have kept a focus on that instrument when the rest of the world became obsessed with emission trading. I am a huge fan of market-based policies, but I don't think the enthusiasts for emission trading appreciated how hard it is

to make a system of property rights work at the international level when the institutions for assigning and enforcing rights are so weak. I ended up spending a lot of time on that problem because it helps explain why emission trading systems in the real world function so differently from the ideal theory – a topic I will take up in this book.

Third, early in 1993 IIASA held a contest for research groups to bid for three years of funding to study international environmental cooperation. I put together a team with many of the academics who were in Cambridge studying environmental issues at the time. We sent off our application and promptly forgot about it. To my shock, we won, and that meant moving to Austria to run the enterprise. I withdrew from graduate school (returning later in the decade for a few months to file my thesis), hired Gene as a co-director, and we set out to study why some international environmental agreements are effective and others not. From the effort I learned a lot about the scholarship and even more about management. I'm proud that our effort funded the international regimes database – led by Oran Young, Marc Levy, Michael Zürn (who had been in Cambridge for a sabbatical and now leads the Hertie School in Berlin), and a young political scientist, Helmut Breitmeier, who carried the regimes database to fruition. We sponsored some of Ted Parson's research on negotiation games and also wrote a big book on the effectiveness of international environmental commitments (Victor, Raustiala, and Skolnikoff 1998). Among the many people involved in the effort were Owen Greene, Chris Stone, Julian Salt, Steiner Andresen, Olav Schram Stokke, Jon Birger Skjaerseth, Jørgen Wettestad, Juan Carlos di Primio, Alexei Roginko, and Elena Nikitina. In addition, Peter Sand, Arild Underdal, Abe Chayes, Georgi Golitsyn, Alexander Kiss, Peter Sand, Tom Schelling, and Oran Young all played helpful roles on our advisory board. Winfried Lang, the senior Austrian diplomat who worked on the ozone layer, came to know of our work and helped us immensely as we tried to apply our findings in practical ways. Inside the climate and ozone talks Jo Butler and Hugo Schally were instrumental, and I thank them. Among our many students, Kal Raustiala and Cesare Romano played especially central roles and it has been a pleasure to collaborate with them in the years since our time at IIASA. Much of what I know as a political scientist about the design and effectiveness of international environmental regimes comes from that time. Along the way, Gordon MacDonald became IIASA's director, and I much

enjoyed working with him on some scientific issues. Gordon was a big figure in geophysics, and from him I learned still more skepticism about political institutions and also something about the value of time. Rather than spend two weeks at the Kyoto conference on global warming we stayed home in Austria and built a model that let us predict future emissions of some nasty greenhouse gases – sulfur hexafluoride (SF_6) and perfluorocarbons (PFCs). Building that model – for which Eddie Löser in IIASA's library was invaluable, as on so many issues – was much more fruitful than watching diplomacy grind along in Kyoto. It also convinced me that the approach in vogue – then and now – to treat all warming gases together in a single basket was bad for the environment and also bad politics. SF_6 and PFCs were so nasty and yet so easy to regulate that a much smarter strategy would have seen the world focus on them separately. But the diplomats weren't much interested in such advice since including all the gases in a single basket gave them the illusion that they were creating more flexibility in the climate treaty. Flexibility is often helpful, but for most of the history of climate talks it has been a ruse to avoid facing hard truths, and by lumping all the gases into a single basket the diplomats missed a big opportunity to tailor regulations around the distinct interest groups that would shape any serious program to regulate each gas. While at IIASA I found some time to build a model of the world transportation system with a young German PhD student, Andreas Schafer, and focused on the practical challenge of introducing new technologies into transportation. Andreas later went to MIT and helped Jake and Ron's team add those kinds of important details to the models that the Joint Program was building. While I am a political scientist, perhaps my sobriety about how quickly the global warming problem can be solved comes from having studied technology so closely with so many wise collaborators.

When I left IIASA I moved (with Gene's help) to the Council on Foreign Relations (CFR). The Council's President, Les Gelb, wanted to create a larger think tank because he rightly believed that applied foreign policy was becoming an orphan in universities. My recollection is that there were three of us young scholars on the payroll at the time – Gideon Rose (now editor of *Foreign Affairs*), Liz Economy (one of the nation's leading scholars on China's environmental policies), and myself. That contingent grew quickly, and I very much enjoyed my time at CFR. My bosses – Gary Hufbauer at first and then Larry

Korb and Jim Lindsay – were tremendously supportive. CFR is a place of constant turnover, and I had a serial army of young research assistants coming and going and always keen to lend a hand. Among them were Lesley Coben (who came with me when I left CFR for Stanford University), Valerie Karplus, and Rebecca Weiner. While at CFR Jesse Ausubel and Brian Lessenberry, Derek Loyd I played squash regularly and starting talking about the plight of the world's forests. With help from the Lounsbery foundation we enlisted some of the world's experts to help us look at the real threats to forests (they are mainly agriculture and ranching, but timbering plays a role) and laid out a detailed vision for how quickly the world's forests could be protected and expanded. That effort taught me a lot about how to tame deforestation as a source of CO_2 (deforestation accounts for perhaps one-seventh the world's emissions of this warming gas, maybe more) and also a lot about how technologies can protect the environment. Our view was that higher yielding agriculture and timber plantations would allow more food and fiber to be supplied from much smaller footprints of land, leaving the rest for nature. Doing more with fewer natural inputs is the essence of sustainable development, and the vision for protecting forests (which Jesse and I published in *Foreign Affairs*) applies to a lot more than just trees. (Jesse has worked extensively with Paul Waggoner to outline such visions in other areas, such as agriculture and industrial ecology.) As in most environmental problems, policies that prescribe hardships – eating less or using fewer wood products – were unlikely to work. Technology, not castor oil, is how most environmental problems get solved. If technological change allows people to lighten their footprint at a cost – in money and effort to change behavior – that they don't much notice then the political prospects for environmental are brighter.

While at CFR I also had the pleasure to work on a few other large projects that came from fruitful collaborations – one on technological innovation and economic growth (with Benn Steil, Richard Nelson, and Dick Foster) and one on genetically engineered foods (with C. Ford Runge). Richard Garwin and I ran a little group at CFR that studied areas where technology had a big impact on foreign policy. Most foreign policy was organized by topic (e.g., arms control) or area (e.g., China); we were geeks who worked on technology and pretty much ran the gamut. He worked mainly on weapons and I on the environment. Both of us were inspired by the view that

technological change drives many political outcomes. Rod Nichols, who at the time was head of the New York Academy of Sciences, chaired a study group that I ran on how technology might influence the problem of global warming. Rod has been a big supporter over the years; from him I learned a lot about technology policy and also how to chair a meeting. (He is a master chairman, and the data flow in meetings with him at the helm is so much higher that everyone has a much better time and learns a lot more from the event. Chairmanship is an under-appreciated skill.) That study group convinced me that one of the many things wrong with international diplomacy on global warming, such as the Kyoto Protocol, was its nearly complete failure to focus on encouraging policies that would accelerate the innovation and diffusion of new technologies. That was not a popular message those days – Kyoto was a darling of most people who called themselves environmentalists – and I touched off a debate that started on the op-ed page of the *Washington Post* with the US government officials who were Kyoto's biggest supporters. Op-eds are short, but my beef with Kyoto was a lot more detailed. Soon I was circulating a full length defense of my position and discovered that I had written a book, *The Collapse of the Kyoto Protocol and the Struggle to Slow Global Warming*. I published that book in 2001 a few weeks before the Bush administration withdrew from Kyoto. The timing was good for sales but it made me uneasy since my vision was an alternative, more effective regime. The Bush administration proved better at bashing the existing regime than building a new one, and when the terror attacks on September 11th 2001 arrived they could ignore this problem (and many others) for a long time. In many ways, the present book picks up where *Collapse* left off.

I left CFR for Stanford University in the fall of 2001 but stayed on as an adjunct fellow. CFR's new president, Richard Haass, gave me a warm welcome and for a few years I worked on foreign policy issues from afar. I had a special pleasure writing, for CFR, a series of presidential speeches that offered three radically different ways of thinking about the climate problem. Margaret Winterkorn provided invaluable research assistance on that effort, which reads well even today. I also ran, with John Deutch and Jim Schlesinger, a task force on energy security – my first experience crafting consensus language with a group of two dozen well-informed and highly opinionated experts on energy from across the US political spectrum. That and

related research benefitted from Divya Reddy, Arathi Rao, Lindsay Workman, Mark Bucknam (who was on leave at CFR from the Air Force for a year), and Sarah Eskreis-Winkler. Lee Feinstein guided the effort admirably, and it was a pleasure to work with him. Later, I chipped in as George Pataki, Tom Vilsack, and Mark Warner, aided by Michael Levi, ran a task force on climate change policy. My academic colleagues are horrified that I spend time on such activities that generate no academic output and occasionally become black holes that inhale time and energy. But they offer some insight into how real-world policy must be crafted and offer some tactile insights into the areas where political disagreements run deep as well as the speed with which political problems can be managed. In later years I have spent similarly huge amounts of time on productive task forces of various types for the World Economic Forum – notably with Armen Sarkissian, Pawel Konzal and Linda Yueh.

Stanford hired me to create and run a new research group – what became the Program on Energy and Sustainable Development (PESD). We were funded by the Electric Power Research Institute (EPRI) and BP, plc. For me, the shift west was an opportunity to make two big changes in my intellectual orientation. One was to focus on Asia, and I spent a huge amount of time on the road in China and India especially, getting a feel for how those economies were evolving. The other was to focus on energy markets more centrally. One of the reasons that climate change is a hard problem to tackle is that analysts think about it as an environmental problem. In reality, its root causes and solutions lie in the functioning of energy markets and in the incentives for technological change within those markets. I needed to know a lot more about those markets. And that's what I did at Stanford, with major studies on the globalizing markets for gas and coal, the experience with power sector reform around the world, and an in depth look at some of the most vexing energy problems such as electrifying poor, rural populations. I believe in fieldwork because what is really happening at the level of plant managers and field operations is often quite different from what's reported in textbooks and academic articles, and thus I dragged my students around the world visiting oil and gas fields, refineries, power plants (lots of power plants), coal mines and such. I regularly crossed swords with bureaucratic administrators over the expense and logistical nightmares surrounding all that, and that was an unpleasant shadow that loomed over much of my time at

Stanford. Administrators play essential roles in every organization, but remote and at times dangerous field research is alien to people who spend their days among palm trees and in air conditioned offices. In a decade I bet our students will look at those experiences as among their most formative. I certainly did.

I had many colleagues at Stanford from whom I learned a lot – among them, Tom Heller, Steve Schneider (who had moved to Stanford from NCAR years earlier), Scott Sagan, Nick Hope, Ken Arrow, Larry Goulder, Mike May, Burt Richter, Lynn Orr, Sally Benson, Mark Thurber, Frank Wolak, Jim Sweeney, Mike Wara, John Weyant, and Hill Huntington. Much of what Stanford did on energy policy revolved around Alan Manne and his network of students and ideas who carried the mantle after Alan passed away. PESD was particularly well run because of the efforts of Kathy Lung, Tonya McPherrin, Michelle Klippel, Bob Sherman, Cassaundra Edwards and many others. During the period I started working on this book Aranzazu Lascurian got me started with very helpful research assistance. I have had the great pleasure to work closely with an array of students and post-doctoral students through PESD. Chi Zhang was there at the beginning and from him I started to learn about China. Mark Hayes, Varun Rai, Jeremy Carl, Richard Morse, Mike Jackson, Sam Shrank, Megan Hansen, Ale Nunez, Sarah Joy, Joshua House, Lesley Coben, Becca Elias, Rose Kontak, Bob Sherman, Ngai-Chi Chung, Henry Tjiong, Ify Emelife, Paasha Mahdavi, Megan Hansen, David Hults, Erik Woodhouse, BinBin Jiang, Narasimha Rao, Gang He, Danny Cullenward, Ognen Stojanovski, Jeff Rector, Peter Lamb, Pei Yee Woo, Xander Slaski, Chris Warshaw, Kassia Yanosek, and Hisham Zerriffi all worked, many as my students, on things that have influenced my thinking in this book. PESD also built a network of overseas collaborators from whom I learned a lot about the real world – James Ball, Rob Shepherd, Barry Carin, Gordon Smith, Kirit and Jyoti Parikh, Adilson de Oliveira, Jose Goldemberg, Felipe Araujo, Gary Dirks, Rob James, Trevor Gaunt, Mark Howells, Alison Hughes, Gary Goldstein, Lindsey Jeftha, Tom Alfstad, Anton Eberhard, Katherine Gratwick, Victor Carreon, Armando Jiminez San Vicente, Juan Rosellón, Li Zheng, Lan Xue, Leming Zeng, Pan Jiahua, Yu Yufeng, Wenying Chen, Christian von Hirschausen, Franziska Holz, Christine Jojarth, Frank Jotzo, John Pezzey, Zheng Lemin, Huaichuan Rui, Peng Wuyuan, Rahul Tongia, Lars Schernikau, Mike Toman,

Bart Lucarelli, Francisco Monaldi, Debashis Biswas, Tirthankar Nag, Amee Yajnik, P. R. Shukla, and Subash Dhar. For a large study on the global gas market we built a constructive partnership with the Baker Institute at Rice University; Amy Jaffe and Jillene Connors helped put that together. PESD's research benefitted from a lot of helpful advice from Pete Nolan, Howard Harris, Chris Hobson, Katrina Landis, Chris Mottershead, Atul Arya, and Bryan Hannegan who sat on a PESD advisory board and often visited our team. Stanford's campus is so beautiful that it was not hard to apply the lessons that Abe Chayes and Gene Skolnikoff taught me long ago: invite thoughtful people, choose a good locale, and treat everyone well.

While at Stanford George Shultz involved me in the North American Forum – a three way venture with senior leaders from Canada, Mexico, and the United States. (It's a talk shop of the type that academics usually abhor but I loved because it gave access to people who did things in these countries – especially Mexico, which is in the midst of so many important political changes.) He and Jim Goodby also welcomed me at the Hoover Institution's task force on energy security. It has been a pleasure to work with them on the practical problems of today. Early in the process of scoping out this book Tom Heller and I had very helpful discussions with Nick Stern (who was in the early days of assembling the team that delivered what became known as the "Stern Report" on climate change, a particularly thoughtful and important assessment of climate economics). Nick asked us about the problem of engaging developing countries, which is one of the most difficult challenges in global warming and an area where existing policies (notably the Kyoto Protocol's "Clean Development Mechanism") were not working well. We suggested that a better approach would focus on big "deals" with large developing countries – that is, packages of policy reforms that those countries would undertake, some with external support that aligned with what those countries already saw as their interests. That discussion got me thinking about how to make those deals work – especially how to use competition to encourage countries to provide reliable information about possible deals and then to honor their commitments once the deal was crafted. Over a couple years working with several colleagues at Stanford we fleshed out what those deals might entail, their practical impact on emissions, and how they might be codified. There aren't many relevant experiences in environmental law, but I found that trade law has handled

a similar problem with accession to the WTO. The idea of "climate accession deals," which plays a large role in this book, emerged from that line of thinking.

Hopefully built into the DNA of this book is a deep understanding of energy and technology markets and an appreciation for where policy can really make a difference. When society confronts really hard problems there are strong pressures on policy makers to avoid costly decisions. The result is symbolic policies – that is, policy ventures that look serious but have no real impact. Figuring out which policies matter and which are smoke and mirrors is crucial. On that front, I am especially grateful to our funders not just because they have supported my research but even more because they have given me windows into understanding when firms actually believe that policy will be relevant. At EPRI, Kurt Yeager and Steve Specker were unfailing in their support; also at EPRI I am thankful to Hank Courtright, Bryan Hannegan, Mike Howard, Revis James, Chris Larsen, Arshad Mansoor, Rosa Yang, Norma Formanek, Rich Richels, Tom Wilson, and Geoff Blanford. EPRI put me on their advisory committee – chaired by Granger Morgan and Ellen Lapson and orchestrated by Barbara Tyran – which was a special pleasure because one-third of the members are regulators. (Jeanne Fox, David Ziegler, David Garman, Ron Binz, Michael Dworkin, Bob Fri, and Ernie Moniz were among the many advisory board members from whom I learned so much.) Academics often forget that most of the energy industry is highly regulated and understanding how regulators think is invaluable. About the same time that I started working on this book EPRI also started its "prism" analysis that looks at the real potential for emission reductions from the power sector; I benefitted from sifting through the assumptions in that analysis in detail, for that is a helpful reminder of what people who are closest to the industry think is practical and how practical policies may affect the deployment of capital. They aren't always right (who is?) but it's a very good place to start. At BP, our relationship was created by Chris Mottershead who linked PESD's work to Peter Hughes (who later went to BG and helped us understand the global gas industry), Tony Meggs, and BP's CEO at the time, John Browne. Chris is a fount of knowledge; he and Atul Arya were immensely helpful in teaching me about the firm. Working with BP has been a reminder of the fickleness of public opinion on environmental matters, which is understandable yet disturbing. It

probably makes it hard for our society to manage truly long-term problems. Those days BP was the environmental darling of the oil industry. (Shell had lost its green shine in the wake of a disastrous protest over its Brent Spar platform in the North Sea.) Today, at this time of writing, it is in the midst of an environmental catastrophe in the Gulf of Mexico that led politicians to paint the company as a villain in America. BP along with EPRI's members – who span nearly all of the largest electric utilities in the US and many overseas – are invaluable for scholars because they deploy massive amounts of capital. If you want to understand technological change at large scale in the energy industry the place to start is by studying the decisions around capital expenditure. Academic scribblers often have lots of ideas of cool technologies that might be deployed and overly clever policies that might be enacted into law, but there is no substitute for looking at deployment through the lens of companies that are on the hook for the billions of dollars if the deal goes sour. The hardest thing for policy makers to do is establish credibility; for investors who make massive fixed capital investments credibility is essential. I learned that lesson through hours of interviews with people responsible for strategy inside companies and plant managers responsible for keeping the lights on. In addition to the severely practical business people already mentioned, I am grateful to Manpreet Anand, Bruce Braine, Andrew Brandler, Roberta Bowman, John Bryson, Xavier chen, Ted Craver, Peter Davies, Gary Dirks, Brent Dorsey, David Eyton, Brian Flannery, Sylvia Garrigo, George Gilboy, Charles Goodman, Edgard Habib, Lew Hay, Dick Hayslip, Chris Hobson, Rick Karp, Gail Kendall, Steve Koonin, Steve Lennon, Wayne Leonard, Rogerió Manso, Drew Marsh, Tony Meggs, Ed Morse, Dave O'Reilly, Maria Pica, Bill Reilly, Cameron Rennie, Jim Rogers, Christof Rühl, Mark Savoff, Dale Simbeck, Greg Tosen, Jim Turner, Phil Verleger, Steve Westwell, Ellen Williams, Jeff Williams, Eileen Robinson, and Dan Yergin for many conversations over the last few years that have shaped how I think about the deployment of capital. Thanks also to Sheryl Carter, Ralph Cavanagh, Reid Detchon, David Hawkins, Fred Krupp, Jonathan Lash, Michael Oppenheimer, Jonathan Pershing, Annie Petsonk, Mark Tercek, and Tim Wirth among many others who spend much time in the environmental community for helpful discussions on the interaction between policy and environmental regulatory strategy. There is no way that all these people in different

communities will agree with what I write here, but hopefully they will find my views well informed by the realities of the energy industry.

Having spent a long time building a research institute that works across disciplines I have come to appreciate others who have done that well. At the top of my list is the Engineering and Public Policy Program at Carnegie Mellon, and it has been a pleasure to work over the years with Granger Morgan, Jay Apt, David Keith, Alex Farrell, Lester Lave, Ed Rubin, Elizabeth Wilson, Hisham Zerriffi, Hadi Dowlatabadi, and others who are part of the CMU orbit. Granger, Jay and I – along with John Steinbruner and Kate Ricke – have spent some time over the last few years looking closely at the challenge of governing geoengineering, and their thoughts have helped inform Chapter 6 of this book. Geoengineering, which is the direct intervention in nature to offset (crudely) the effects of global warming, matters because it may be the best way to buy some time if climate change turns ugly. Dieter Helm and Cameron Hepburn invited me to develop these ideas in more detail in an essay they published in the *Oxford Review of Economic Policy*; along the way, Scott Barrett, David Keith, Ken Caldeira, Steve Rayner and especially Tom Schelling have also influenced my thinking about how to manage geoengineering.

While at Stanford I joined the faculty at Stanford Law School. Dean Larry Kramer was the key person behind that appointment, and I am forever grateful for his support. I had terrific colleagues, among them Josh Cohen, Deborah Hensler, Michael Wara, Buzz Thompson, Mitch Polinsky, Al Sykes, Richard Morningstar, Tino Cuellar, and Mark Kelman. Josh Cohen, who was also editor of *Boston Review* (a literary magazine), commissioned a huge essay on the global coal market for his magazine – a brave move in a publication more accustomed to fine literature than strip mining. It is one of the publications in the last decade of which I am most proud. No plan for slowing global warming can work without an answer for coal.

I left Stanford for the University of California San Diego in summer 2009 and here in San Diego I am making still another big shift. With my partner and colleague, Emilie Hafner-Burton, I am building a laboratory that studies the effectiveness of international law. Some of our thoughts are reflected throughout this book, which is really a full length examination of how to make international law more effective in the area of climate change. I am grateful to Peter Cowhey who worked with Miles Kahler, David Lake, Barb Walter, Paul Drake

and others to bring us to UCSD. I am also delighted to work with them and other new colleagues – among them James Fowler, Peter Gourevitch, Josh Graff-Zivin, Steph Haggard, Tony Haymet, Charlie Kennell, Yon Lupu, Walter Munk, Ram Ramanathan, Fang Rong, Susan Shirk and Linda Wong. For help getting our lab up and running efficiently, many thanks also to Amanda Brainerd, Derek Brendel, Jill Coste, Teresa Olcomendy, Elizabeth Rich, Amy Robinson, and Brent Wakefield. The UCSD move has allowed me to spend more time closer to my professional roots, which are in political science. And a special thanks to EPRI and BP who, as earlier, have been unfailing supporters of my research.

This book is the third I have published with Cambridge University Press, and for that I thank the wonderful Chris Harrison, my editor, and Philip Good who assists him so ably. A special thanks to Chris and two anonymous reviewers who gave me a good steer on the penultimate draft of the manuscript – leading, I hope, to a more coherent and better written story. Hank Courtright, Frank Jotzo, Charlie Kennell, Bob Keohane and Steve Specker all read parts (or all of) that draft and for their detailed comments I am most grateful – notably to Bob who sifted through the full argument in detail. And thanks to Linda Wong at UCSD who signed on to help me with references and ended up doing much more, from editing and advising on writing strategy. At various stages in the preparation of this manuscript I gave talks at Stanford, Yale, UCSD, Northwestern, Entergy Duke (the university and the energy company), Columbia, the Salt River Project, EPRI, BP, Chevron, and Harvard; thanks to those seminar participants for feedback. Rob Stavins and Joe Aldy edited two books on global warming policy and invited me to publish a chapter in each – those chapters help develop some of the core ideas in this book. A special thanks to everyone who has disagreed with me over the years – a long list – for their objections have helped me sharpen my message.

In the midst of our move, Emilie and I had a wonderful son, Eero. Surely the vagaries of life will lead him to do things other than worry about global warming, but given the slow pace of serious efforts to tame this problem my guess is that his generation (and the next one too) will still be struggling with the issues I discuss in this book.

Hard truths about global warming: a roadmap to reading this book

After two grueling weeks of negotiations, late in 2009 the Copenhagen conference on global warming ended with a whimper. On nearly every major agenda item, including the need for a new treaty to replace the aging Kyoto Protocol, the meeting failed to produce a useful agreement. Diplomats did the easy things, such as making bold proclamations that global warming should be stopped at 2 degrees and promising huge new sums of money to help developing countries control their emissions and adapt to the changing climate. They also invited countries to make pledges for how they would contribute to these planetary goals.[1] In the months since Copenhagen, analysts have shown that those national pledges won't come close to stopping global warming at 2 degrees.[2] Many of the pledges are missing serious plans for how they will be fulfilled. And the new financial promises for developing countries are also slipping away. Even worse, while everyone agrees that more formal global talks are needed, there is little consensus on the best strategy.

As global talks have become stuck in gridlock, the picture inside the countries whose policies will matter most in determining the future of global warming isn't any more encouraging. Of the industrialized countries, for many years the members of European Union (EU) and Japan have made the biggest policy efforts. But these countries account for just 18 percent of world emissions and their share is shrinking.[3] The other big industrial emitters, notably the US but also Canada and Australia, are doing very little. The most encouraging news in the run-up to Copenhagen came from developing countries. These countries, which account for nearly half of world emissions, have historically refused even to discuss emission controls because they had other priorities such as economic development. But through the Copenhagen process all the largest developing countries pledged to slow the growth in their emissions. However, behind that