Transforming Energy
Solving Climate Change with Technology Policy

Climate change will be an ecological and humanitarian catastrophe unless we move quickly to eliminate greenhouse gas emissions. Policy experts advise us that we need to make major changes to our lifestyles, and our governments need to agree to globally binding treaties and implement market instruments like carbon taxes. This advice is a mistake: it treats technological innovation as being at the periphery of the climate policy challenge. Instead, technological innovation needs to be at its core; we will phase out emissions when and only when the technologies to replace fossil fuels are good enough, and policies need to support these new technologies, quickly and directly. Anyone with an interest in climate change and energy policy will find this book forward-thinking and invaluable. Professional policy makers, climate and energy policy researchers, and students of energy and public policy, economics, political science, environmental studies, and geography will find this book especially stimulating.

Anthony Patt is Professor of Climate Policy at ETH Zurich, the Swiss Federal Institute of Technology. He had been a practicing environmental lawyer in the United States when his concern about climate change led him to Harvard University's Kennedy School of Government, where he earned a PhD for research on the relationships among science, engineering, and climate change governance. Since moving to Europe in 2006, he has turned his attention to the policy challenges associated with scaling up low-carbon technologies. In 2012, he received the prestigious European Research Council award to support his team's research on the environmental, social, and institutional challenges of solar energy development. From 2011 to 2014, he participated in numerous capacities in the preparation of the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, including as Lead Author on the role of risk and uncertainty in climate policy and as a member of the writing team of the Summary for Policymakers for the IPCC's *Mitigation of Climate Change* report. He lives with his family in a highland farming community near Zurich and spends his free time in the mountains, gardening, and making things with wood.

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For my children, Luz and Seon

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Foreword

Barely a month goes by without some more bad news about global climate change. The bad news about the impacts of torqueing the climate system is easy enough to understand. Humans are adding increasingly larger amounts of warming gases to the atmosphere, and the climate is now responding. Ice sheets are melting – some irrevocably, it seems – the seas are rising, and weather patterns are changing. Given the size and rate of the human thumb on the climate, the impacts are, for the most part, harmful. The climate is a complex system whose interactions are not understood perfectly. By pushing around a complex system, humans are setting themselves up for unpredictable and possibly horrible outcomes. And since that system is important – nothing less than the planet's life support system – we shouldn't do that lightly.

In recent years, though, a string of bad news has also appeared on the political front. Despite more than two decades of diplomacy and national policy discussions about climate change, there's almost no evidence that emissions – the root cause of the problem – have responded. Global emissions from the energy sector are higher than ever before and not set to reverse any time soon. Sure, a few jurisdictions – notably in Europe – have made cuts, but those have come often at huge cost and concern only a small fraction of the global total. Growth elsewhere, especially in the emerging economies, has been overwhelming.

It is easy to despair. The science around global climate change seems to suggest that the problem is getting worse quickly – with harms that are, on balance, worse than previously thought. And the experts on political systems are finally realizing that solving this problem will be a lot harder than anyone thought.

So what should be done? This book suggests some answers.

The goal of climate policy must be deep cuts in emissions. And to get deep cuts, there must be radical systemic change, foremost in the energy sector. On this front, Anthony Patt sings with the chorus. Politically and practically, there is almost zero chance that humanity will solve the climate crisis by tinkering at the margins with our energy systems or simply asking people to use less energy.

But as this book unfolds, a message appears that is much more challenging to conventional wisdom. The policy instruments that most experts think will boost innovation and cut emissions don't work. Market-based systems – such as cap-and-trade or emissions taxes – are lovely in theory, but, in practice, they don't seem to have much impact on behavior. The root of this failure isn't just that the prices for emissions are too low. Instead, as Patt shows, the problems are structural. Market-based systems are good at sending signals to individual actors over short periods of time, but they aren't very good at coordinating and creating confidence around massive system-wide changes in whole infrastructures. Yet that's what is needed.

Market policies are important. But even more important is a strategy that requires government to take a much more active role. That is the essence of this book. At a time when the policy experts are lambasting policies that involve picking winners, Patt offers us something different: the case for well-designed, careful interventions to support key technologies and ideas that could be the building blocks for a low-emission future. Real change comes from creating niches in which profoundly new technologies and business practices can thrive; and from those niches, the best approaches can spread. That's what will drive a fundamental transition – not efforts to tinker at the margins with small changes in carbon pricing or national emissions targets that represent only a small departure from business as usual.

So far, we haven't seen that kind of profound change in the world's energy systems, and the schemes most experts suggest are unlikely to deliver what is needed. At the same time, innovation in some key technologies has exceeded expectations of even a few years ago, to an extent that may be fundamentally altering the playing field. So, how should government intervene more decisively, building on this latter fact? What is the right role for firms – including state-owned firms – that must manage investment risks? How should policy makers design their interventions so they learn from mistakes and adjust? What is the right blend of carbon pricing and direct regulation? How can we lock in low-emission trajectories so that early innovations build upon themselves into larger markets while locking out dirtier

pathways? These are the questions that Anthony Patt forces us to think about, with elegant prose and informative vignettes from his own career. They are the questions we must all grapple with as we search for new models to guide climate policy.

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I am indebted to a whole lot of other people for what I have learned from them, ideas that have coalesced into this book. The first of these is Dan Schrag, one of my PhD advisors and a friend ever since. About ten or twelve years ago, at a time when I was convinced that the *sine qua non* of effective climate policy was a set of market instruments embedded in a strong international framework, Dan challenged me on that. The strength of his challenge caused me to begin to question and, ultimately, turn my thinking around.

Several colleagues at my former institute, the International Institute for Applied Systems Analysis (IIASA), helped me in major ways. Most of all, my supervisor and mentor there, JoAnne Bayer, encouraged me to extend my research agenda outside of climate adaptation and to apply the tools for thinking about social attitudes toward risk to the study of climate mitigation. IIASA was a perfect place to do so, simply because it was a meeting point for many of the leading minds in energy policy. The people who made that happen, and who

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