

Energy for Change

Introduction to the Special Issue on Energy & Climate

Without energy, there is no economy. Without climate, there is no environment. Without economy and environment, there is no material well-being, no civil society, no personal or national security. The overriding problem associated with these realities, of course, is that the world has long been getting most of the energy its economies need from fossil fuels whose emissions are imperiling the climate that its environment needs.

Compounding that predicament are emissions from land-use change—above all, deforestation in the developing countries of the tropics. Like society's choices about energy supply and use, this process has been driven by powerful economic and political forces insufficiently moderated by understanding or consideration of the environmental component of societal well-being.

This is no longer a hypothetical or distant issue. It is real and it is upon us. The climate is changing markedly nearly everywhere. The air and the oceans are warming, mountain glaciers are disappearing, permafrost is thawing, sea ice is shrinking, the great land ice sheets on Greenland and Antarctica are slipping, and sea level is rising. And the consequences for human well-being are already being felt: more heat waves, floods, droughts, and wildfires; tropical diseases reaching into the temperate zones; vast areas of forest being destroyed by pest outbreaks linked to warming; hurricanes and typhoons of greater power; and coastal property increasingly at risk from the surging seas.

All this is happening faster than was expected. Sea level is rising at twice the average rate for the 20th century. The volume of sea ice in the Arctic (its area times its average thickness), which reaches a seasonal minimum every September, appears to have been smaller in September 2008 than in any year of the last 30—

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the period in which we've been able to estimate this variable. In that same 30 years, the average area annually burned by wildfires in the western United States has quadrupled.

Nor is the primary cause of these changes any longer in serious doubt. The primary cause is the emission of carbon dioxide and other heat-trapping pollutants from our factories, homes, offices, vehicles, and power plants, and from land clearing. We also know that failure to curb these emissions will bring far bigger impacts

from global climate change than those experienced so far. Drastic changes in weather patterns, sharp drops in the productivity of farms and ocean fisheries, a dramatic acceleration of species extinctions, and inundation of low-lying areas by rising sea level are among the possible outcomes.

But we also know what we can and must do to avoid the worst of these possibilities. We must work together—East and West and North and South—to transform our technologies for supplying and using energy from polluting and wasteful to clean and efficient.

Without energy, there is no economy. Without climate, there is no environment. Without economy and environment, there is no material well-being, no civil society, no personal or national security. The overriding problem associated with these realities, of course, is that the world has long been getting most of the energy its economies need from fossil fuels whose emissions are imperiling the climate that its environment needs.

We must create new incentives and agreements to accelerate this transformation, and to bring deforestation and other destructive land-use practices to a halt around the world. And we must invest in adaptation efforts to reduce our vulnerability to the degree of climate change that can no longer be avoided.

We can do this together. And when we do, we will benefit not only by avoiding the worst damage from climate change, but also by reducing our perilous overdependence on petroleum, alleviating the air pollution that afflicts our cities, preserving our forests as havens for biodiversity and sources of sustainable livelihoods, and unleashing a new wave of technological innovation—generating new businesses, new jobs, and new growth in the course of creating the clean and efficient energy systems of the future.

The key question we now need to heed about what the science of climate change is telling us is how much progress we need to make with these measures, and how quickly, to have a good chance of avoiding climate changes more extreme than our adaptation efforts will be able to manage. And the science is increasingly clear in pointing to the conclusion that it will be essential to hold the global average temperature increase to no more than two degrees Celsius if we are to keep climate change to a manageable level.

It is likewise clear that if we are to have a good chance of meeting this goal, global emissions of carbon dioxide and other heat-trapping pollutants must level off by about 2020 and decline thereafter to something like 50 percent of the current levels by 2050, with continuing declines after that. Allowing for the larger historical responsibility and much higher current per capita emissions of the industrialized countries and for the development trajectories and aspirations of the developing ones, the most likely way to achieve this goal would be for the industrialized world to level off its emissions by 2015 and reduce them thereafter to around 20 percent of current levels by 2050, with the developing countries following after a lag of about a decade, leveling off their emissions by about 2025 and reducing them after that.

These are targets that we can meet. As the content of this special issue of *Innovations* illustrates, the solutions to our climate challenge aren't just "out there," they are right here—before your eyes, in your hands. Climate solutions are in California, which thirty years ago charted a course toward energy efficiency that other states are only now beginning to follow. They are in Brazil, which generates 50% of the fuel used in its cars from home-grown sugarcane. They are in New Hampshire, where a company started by a former nuclear engineer is working to develop the carbon capture and storage technologies that will be essential for a cleaner coal future. They are in Hawaii, where plug-in electric vehicles are quietly becoming a reality. And they are in Arkansas, where the world's biggest company—Walmart—is establishing standards for energy use and carbon reductions that will apply not only to its global operations but to its entire supply chain.

These and the other innovations described in this special issue are not isolated anecdotes. Nor are they elements of any single grand plan. They are simply a few of the many pathways to progress created every day by citizens, by the businesses that serve them, and by the governments that represent them. Such pathways derive from another other type of energy vital to addressing our climate challenges: the creative energy of people who, through ingenuity, partnerships, and collaborations, are able to cut through complexity to arrive at practical solutions. We can ask for no better guides than they to lead us toward the prosperous and secure future to which we all aspire.

CONTENTS OF THE SPECIAL ISSUE

The publication before you is as thorough a survey of energy and climate solutions as has yet been compiled. Like other issues of *Innovations*, it is organized into four

sections: lead essays; cases authored by innovators (each accompanied by a commentary); integrative analytic papers; and perspectives on policy.

Lead Essays

The lead essays are authored by a formidable group of energy and climate policy veterans.

First among them is Thomas Schelling, recipient of the Nobel Prize in Economics in 2005 (jointly with Robert Aumann) and chair of the first committee of the National Academy of Sciences to study global warming. Schelling makes a compelling case for a new institutional architecture to support international collaboration to address the climate challenge. Specifically, Schelling points out that the countries most likely to suffer adverse impacts from climate change are also, in most cases, the ones least well equipped to adapt their energy infrastructures to reduce carbon emissions. Advanced industrialized countries have an opportunity to reduce adverse impacts from climate change while improving welfare for the majority of the world's population by both increasing and better structuring energy and climate assistance to developing countries.

The second lead essay is authored by Vinod Khosla, a founder of Sun Microsystems, a general partner at the venture capital firm of Kleiner Perkins Caufield & Byers, and the founder of Khosla Ventures, a major investor in energy technologies. Khosla applies the deal-making acuity that has made him one of America's most successful private-equity investors to the task of proposing a way forward with climate negotiations that would be acceptable to both developed and developing countries. Khosla makes the case that even when countries agree on the urgency of the climate challenge and on the most efficient mechanisms to achieve needed carbon reductions, potentially deal-breaking disagreements may exist about the fairness of different approaches for defining and sharing responsibility. He proposes an approach aimed at aligning the objectives of carbon reduction and economic growth, while at the same time allocating responsibility for progress in an equitable manner.

The third lead essay is by Eileen Claussen, President of the Pew Center. Focusing on policy at the national level in the United States, Claussen emphasizes the benefits to business of policy certainty during the transition to a lower-carbon economy. She quotes George Nolen, president and CEO of Siemens Corporation: "Businesses need to plan. The absence of a price signal for carbon in the U.S. stifles planning and creates a competitive barrier to investment in technology." Creating a price signal for carbon, she argues, is a prerequisite if the U.S. is to realize the job creation and growth gains that will accompany the shift toward clean technologies.

The fourth lead essay is written by Bill Drayton, founder and chairman of both Ashoka: Innovators for the Public and of Get America Working. Drayton is today best known as a leading figure in the field of social entrepreneurship. Three decades ago, however, Drayton made another contribution directly relevant to the

theme of this volume. At the Environmental Protection Agency, he set up the world's first system for emissions trading. Others had floated the idea, but Drayton took the lead in implementing it. Today, the same principle of emissions trading has been accepted throughout the world as the best approach for achieving targeted reductions in emissions while maximizing economic efficiency. Like Claussen, Drayton emphasizes the need to get prices right. He focuses on the tax system, arguing that it makes no sense to subsidize the use of machines by keeping energy prices low while penalizing the use of labor through payroll taxes. Urging structural changes in the economy to “favor people, not things,” he advances a proposal to both create jobs and meet climate goals by reducing the tax on employment and increasing the tax on gasoline.

Cases Authored by Innovators

The second section of this issue features four cases authored by innovators. Each of these addresses a different domain of energy and climate solutions. The first two describe initiatives spanning decades that have had large-scale impacts in California and Brazil, respectively. The second two describe new ventures that hold promise for the future.

The first case narrative is by Arthur Rosenfeld, a pioneer in the design and implementation of policies to encourage energy efficiency whose “laboratory” for this work has been the State of California. (That per capita electricity demand stayed constant in California over the past three decades while rising 50 percent in the rest of the United States is widely known as “the Rosenfeld effect”.) In a fascinating retrospective, Rosenfeld describes how energy efficiency was first “invented” as a concept relevant to public policy and then embedded into a set of strategies for dramatically shifting the trendline of energy consumption in the nation's largest state—still perhaps the greatest success story during the past 30 years of U.S. energy policy.

The discussion of the California experience in achieving efficiency gains is written by Ralph Cavanagh, Energy Program co-director at the Natural Resources Defense Council. Cavanagh starts with a wonderful anecdote: “Late in 2006, soon after Governor Arnold Schwarzenegger signed into law California's path-breaking curbs on greenhouse gas emissions, a reporter asked California Energy Commissioner Arthur Rosenfeld when statewide reductions would start showing up. ‘Around 1975,’ he replied.” The point is clear: future carbon reductions in California—and, Cavanagh, argues, elsewhere in the U.S.—are not only possible, they are to be expected as a direct extension of past successes. Other regions and countries can achieve substantial carbon reductions with a minimum of creativity or risk-taking simply by following the strategies—such as electricity and natural gas rate “decoupling”—employed successfully in California.

The second case narrative in the issue is by José Goldemberg, a professor at the University of São Paulo who has held many positions of national and international distinction over the span of his 50-year career as a scientist and public servant.

He is among the world's most respected voices on energy policy. Goldemberg's case narrative describes the origins and evolution of Brazil's world-leading biofuels program, of which he was among the principal architects. Placing Brazil's experience in a global context, Goldemberg describes the potential that exists for Brazil and other developing countries to create jobs and contribute to meeting carbon targets by producing ethanol for export.

Melinda Kimble, a senior vice president at the U.N. Foundation, offers a discussion of the Goldemberg case. Kimble, who oversees the foundation's International Biotechnology Initiative and who previously served as an Assistant Secretary of State, emphasizes how Brazil's success in shifting its energy mix derived from its creativity in finding multiple uses for sugarcane and its by-products. The central lessons to be learned from Brazil's experience, according to Kimble, pertain not to ethanol itself, but rather to the value that can be created by policies encouraging market flexibility and resource optimization.

The next case narrative tells the story of a new company with a big vision—Better Place, which seeks to make electric vehicles a wide-spread reality. As described in this narrative by the company's founder, Shai Agassi, Better Place has undertaken new approaches to developing and deploying electric-vehicle driver services, systems, and infrastructure. In the Better Place models, subscribers and guest users have access to a network of charge spots, switch stations, and systems that substantially increase driver convenience while minimizing environmental impact and cost.

Daniel Kammen, founding director of the Renewable and Appropriate Energy Laboratory at the University of California-Berkeley and the co-director of the Berkeley Institute of the Environment, offers a discussion of Agassi's case. Kammen begins by pointing to the regrettable failure in the U.S. to make headway on vehicle efficiency for a period of two decades, from the mid-1980s to roughly 2005. Clearly, Kammen points out, the time has come to get the ball rolling again. The question is, along what path? Kammen summarizes the alternatives. He then encapsulates the challenge that Agassi and his team at Better Place face in bringing about the system change required so that electric vehicles are competitive not only with today's conventional vehicles, but also with the improved internal combustion engines and hybrid-electric cars that are on the horizon.

The final case narrative is the story of Powerspan, a company that develops and sells carbon capture technologies. The company's founder and the author of the case, Frank Alix, describes with clarity both why carbon capture and storage (CSS) technologies are of potentially great importance in meeting carbon-reduction targets and how the development and widespread deployment of CSS technologies represent a complex business challenge. At the same time that he describes a significant climate solution, Alix also offers a compelling entrepreneurial narrative. Here is a man who, trained as a nuclear engineer and about to embark on a career building submarines for the Navy, is faced with the end of the Cold War and a sudden, wholly unexpected decrease in his professional prospects. Looking for new opportunities, Alix eventually rededicated himself to a new challenge vital to

national security: the reduction of carbon emissions from coal-powered energy plants. The result, after over a decade of entrepreneurial perseverance, is the company that today is Powerspan.

The discussion of the Powerspan case is authored by Granger Morgan who leads the Department of Engineering and Public Policy at Carnegie Mellon University and is one of our country's most thoughtful experts on energy policy. Morgan offers a concise and lucid exposition of the challenges that must be overcome before CSS technologies can contribute significantly to meeting the climate challenge. Observing correctly that the very existence of markets for environmental-control technologies is predicated upon regulatory action, Morgan summarizes the dimensions of public action required before the potential benefits of CSS technologies can be realized. He concludes that "while technical innovation will be a critical part of the successful large-scale deployment of CCS, innovation in public policy and law will likely be as or more important."

Analytic Essays

The case narratives in the issue cover four areas of potentially great significance to creating climate solutions: improving energy efficiency, creating substitutes for oil, enabling coal to be burned more cleanly, and developing the infrastructure to make electric vehicles a reality. The analytic essays address two more: creating the safeguards and building the institutional capacity to enable a next generation of nuclear power, and combining standards and innovation to dramatically improve the efficiency of energy use in buildings.

The future of nuclear power is the subject of a set of four essays respectively authored by Matthew Bunn and Martin Malin of Harvard's Kennedy School of Government; Tariq Rauf and Zoryana Vovchok of the International Atomic Energy Agency; Roger Howsley, former director of Security, Safeguards and International Affairs (SSIA) for British Nuclear Fuels Ltd.; and Charles McCombie, formerly scientific and technical director of Nagra, the Swiss Cooperative for the Disposal of Radioactive Waste. The authors of these essays are professionals with nearly a century of combined experience related to nuclear energy and security policy — people who understand well the particular characteristics that make nuclear power simultaneously one of humanity's most promising and most contentious creations. As a large-scale energy-production technology that generates zero carbon emissions in use, nuclear power is in the midst of a potentially welcome resurgence. The growth in the use of nuclear power and the contributions that such growth could make to addressing the climate challenge are at risk of being cut short, however, if accidental or deliberate catastrophes (e.g. another Chernobyl, use of civil plutonium in a nuclear weapon that explodes in a city) cannot be avoided. The nuclear industry and all of us share an interest in driving the risk of such catastrophes as close to zero as possible. This collection of essays describes improved nuclear safety, security, and nonproliferation controls—including new

institutions and agreements—whose implementation could enable the nuclear industry to grow responsibly and safely.

Multiple authors with deep experience in energy policy collaborated to produce a set of essays on strategies to improve efficiency in buildings—what my colleague, Secretary of Energy Stephen Chu, has described as the “low-hanging fruit” in our efforts to reduce carbon emissions both at home and abroad. Jim Turner, former chief counsel for the Science Committee of the U.S. House of Representatives, has joined with Ellen Vaughan, policy director of the Environmental and Energy Study Institute, and Colin McCormick, an energy specialist with the Federation of American Scientists, in examining this claim by showing the magnitude of possible savings from buildings, the current state of energy efficiency knowledge and use in the United States, and the changes that must occur before we can start realizing the large reductions in carbon emissions that are possible through the more efficient use of energy in buildings. A second essay, written by Henry Green, the president of the National Institute of Building Sciences, describes how his organization is helping craft standards to enable a future of high-performance buildings that are not only far more energy efficient than today’s, but that also incorporate significant advances in safety, security, and accessibility. In a third essay, Franz Beyeler, the chief executive officer of Minergie, his colleague Nick Beglinger, and Ursina Roder of the Embassy of Switzerland to the United States, describe Switzerland’s success in improving the energy efficiency of the built environment through voluntary energy standards.

The last of the three analytic essays is authored by Hunter Lovins, the founder of Natural Capitalism, Inc. and one of America’s most expressive voices on the topic of benefits attainable through improved energy efficiency. Lovins provides a systematic survey of initiatives that companies and municipalities have undertaken unilaterally to address the climate challenge. Along the way she describes what she terms “the economic case for climate action.” Lovins notes that leading U.S. companies including DuPont, G.E., Alcoa, Caterpillar, and PG&E, acting as members of the U.S. Climate Action Partnership, have called for national legislation to cap carbon emissions, stating, “In our view, the climate change challenge will create more economic opportunities than risks for the U.S. economy.” Lovins further describes how cities, states, campuses and others are implementing climate-protection efforts, and in so doing “cutting their costs, creating jobs, and enhancing their economies by reducing their carbon footprint.”

Perspectives on Policy

In the final section of the energy and climate special issue, two pairs of authors take a step back from specific innovations in practice to offer their perspectives on the design and implementation of climate policies.

William Bonvillian of MIT and Charles Weiss of Georgetown University focus on the challenge of undertaking large-scale innovation in energy and other established sectors of the economy that are complex and capital intensive. The core

metaphor of their essay is a colorful and illuminating one: Americans know well how to bring real and metaphorical “covered wagons” West and build on frontiers of various types; however we have less experience, and are arguably less adept, in taking those same covered wagons East—that is, innovating in established technological and social domains. Our energy systems, like our healthcare systems, are complex and interconnected. In such settings, success in addressing future challenges and realizing future opportunities may require a new innovation framework—one vision of which is offered by the authors.

In a second perspective on policy, Daniel Kammen, introduced above, and Felix Creutzig, a postdoctoral fellow and associate at the Technical University Berlin, have coauthored an essay that emphasizes the need for adaptability in international accords to ensure that different geographical regions are able to realize fully the societal benefits that they can derive from a transition away from carbon. To exemplify the need for such an approach, the authors focus on two domains: rural regions in Africa and cities in the industrialized world. The authors argue that putting a future international climate accord into a local context and relating mitigation measures to “co-benefits” of a carbon transition not only will increase political acceptance of any accord reached but also will advance other important sustainable development objectives.

CHANGE THAT SURROUNDS, CHANGES THAT PROPEL

The many impressive innovations and visionary ideas described in this volume are all the more inspiring as one comes to understand that they are but a few of many. Just as we are surrounded by evidence of a changing climate, so are we surrounded by climate solutions in the making. There was not room in this issue to come close to covering them all, with wind, geothermal, advanced solar-electric technologies, the smart grid, direct solar-to-liquid-fuel conversion, better biofuel options, new battery technologies, resource-conserving urban and transport-system design, and advanced manufacturing technologies among the innovations getting short shrift here.

Meeting the energy-climate challenge—supplying the expanded energy services required to create and sustain economic prosperity for everyone on the planet without wrecking the global climate on which well-being equally depends—is likely to be the toughest task that science, technology, and innovation policy will face in this century. But I have no doubt that with education about the stakes and opportunities, the political will created thereby, and the ingenuity and entrepreneurial spirit exemplified by the stories and ideas in this special issue of *Innovations*, we will find that “Yes, we can.”