Social Sciences & the Alternative Energy Future

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Three decades ago the United States, Japan, and the European nations entered into a treaty to limit the use of chlorofluorocarbons (CFCs) and other ozone-depleting chemicals. Scientists at that time concluded that industrial and residential use of CFCs and similar chemicals had caused significant loss of ozone high in the atmosphere, especially over the polar regions. There was further consensus that the thinning of the stratospheric ozone layer would increase human exposure to ultraviolet rays, which can cause skin cancers and other adverse health effects, and would degrade the environment in other ways. The Montreal Protocol on Substances that Deplete the Ozone Layer was signed and put into effect in 1989, and it is expected that the damage to the ozone layer will be largely repaired by 2050.[1]

Worldwide cooperation can solve global environmental crises.[2] The Montreal Protocol stands as a clear example of such concerted action. Yet there are notable differences between the global action required to respond to climate change and what was necessary in the case of CFCs. Looking back on the experience with CFCs and the Montreal Protocol, Nobel Prize-winning chemist Mario Molina noted that the global warming challenge is as much a matter of public policy and social science as engineering, physics, and chemistry. In fact, the science behind carbon emissions and climate change is far more certain now than the science behind CFCs and ozone depletion was in 1989.[3] The vastly different political responses to these two environmental challenges can be explained by their particular root causes. On the one hand, the technologies accounting for most of the ozone-depleting chemicals were highly concentrated in a few industries, and close substitutes for CFCs existed. CFCs could thus be isolated and addressed through relatively straightforward regulatory regimes.

On the other hand, greenhouse gas emissions from human activities come primarily from burning fossil fuels for electricity and transportation. Those activities are not isolated to a few industries: electricity and transportation are integral to nearly every aspect of modern economies and societies. To curb global carbon emissions we must fundamentally alter the ways that we consume and produce energy. And unlike CFCs, fossil fuels do not currently have inexpensive alternatives that would deliver the same amount of energy for economic activities at a global scale. For these reasons, the path forward on climate change will be very different from the story of CFCs.

Two issues of *Dædalus* have examined the Alternative Energy Future. The essays in this volume and its earlier companion (Spring 2012) offer various perspectives on what that future might be and how economic, social, and political decisions made today will shape energy use and the environment over the next fifty to one hundred years. The central theme of these issues echoes Mario Molina's insight: the problems are as much social, political, and economic as they are technological. As a result, the expertise of social scientists, historians, business leaders, legal scholars, and policy-makers will be essential to understanding what an alternative energy future might be and how it might be achieved. Our purpose in this concluding essay is to explore how best to link energy policy and the social sciences.

To understand the nature of this linkage more clearly, we have supplemented the views of social scientists represented in this volume with those of respected thinkers in the energy and climate fields. We conducted an informal poll of thought leaders in the current policy debates, especially Steven Koonin, Director of New York University's Center for Urban Science and Progress and former Under Secretary for Science at the Department of Energy; environmental economist at MIT and the Brookings Institution Michael Greenstone; and Rebecca Henderson, business economist and Codirector of the Business and Environment Initiative at Harvard University. We also reviewed highly regarded reports from the National Academy of Sciences, the American Association for the Advancement of Science, and the President's Council of Advisors on Science and Technology. We wanted to identify the specific questions that are prominent in the energy and climate policy communities. To summarize our findings, we have outlined six key areas of crucial policy questions.

First: Understanding the Consequences and Risks of Inaction. Current climate policy in the United States, China, and other countries amounts to addressing future events that may happen as a result of changes in the climate as they become evident. In short, we are taking our chances on adaptation.

This policy might make sense if the associated risks of inaction are tolerable. If not, the policy could be very costly. Thus, a research priority should be to pin down the potential consequences of a changed climate and, crucially, its impact on human activities. What concrete changes can we expect in key factors such as the amount and location of arable land and potable water, the frequency of catastrophic storms, and so forth? What are the costs and benefits associated with these changes? For example, rising global temperatures will likely reduce the amount of arable land in Mexico and the Central United States, but the amount of arable land in Canada might increase. What are the projected effects on nations' GDPs? What migration patterns might we expect as a result? How might changes in water supplies and arable land affect international relations and the probability of wars or civil wars? In addition to comprehensive assessments of longer-term consequences, there is a need for understanding how such projections can be used to make decisions today. What sorts of risks are insurable, and which are not? Which are likely to occur and be highly damaging when they do, and how might they be addressed?

In short, social scientists working with policy-makers can develop appropriate modeling tools for decision-making. Such tools would assess the outcomes and scenarios that people living in particular parts of the nation will likely face, and then would identify possible ways to mitigate the risks. For example, rising sea levels over the next fifty years will begin to inundate low-lying areas of coastal cities such as New Orleans, Miami, Boston, and New York. That prospect ought to guide urban planning, zoning, and development decisions in these cities so as to avoid even greater problems in a few decades.

Different approaches to solving this problem also have consequences – economic, environmental, and social. The Stern Review, for example, projected that 2 percent lower economic growth over a century would avoid some of the worst climatic outcomes.[4] That would amount to a long-term economic recession in many countries, which would adversely affect the health and well-being of people living in those countries. Expansion of certain technologies, such as some forms of nuclear power, might bring other risks. We need continued modeling of the possible consequences of the business-as-usual approach as compared with alternative energy futures.

Second: Behavior. Here, *behavior* refers to how people decide to use energy. There has been a significant push to study energy use by individuals, households, and companies. Of particular interest is the use of behavioral psychology to influence people's energy consumption, such as providing people with feedback about their monthly electricity bill or their energy use compared to their neighbors. Information can be extremely powerful, reminding us of what is important or showing us something about our behavior that we hadn't noticed. There are many different mechanisms for providing information to energy consumers (be they firms, households, or governments), whether it is given at the point of use or summarized later in energy bills; is expressed in terms of utilization, emissions, and costs; or emphasizes improvements, targets, or data about other consumers. Many studies find that incremental changes in behavior are possible when people are given information or simple nudges; however, it is not yet clear how long-lived those effects may be. There needs to be a systematic evaluation of what works and why.

The thorniest issue is how to get people to care. In their 1994 article "The Energy Efficiency Gap," economists Adam Jaffe and Robert Stavins describe the "energy paradox": that is, the apparent disconnect between availability and use of technologies that improve energy efficiency. Technologies such as energy-efficient appliances, insulation, smart thermostats, and motion sensor lights ostensibly could save households and businesses considerable amounts on their annual energy expenses, but households and businesses underinvest in such items.[5] If the economic gains from efficiency are real, then why can't we capture them? One important behavioral problem lies in the nature of energy costs. Energy costs are a very small fraction of the cost of renting and operating most businesses, purchasing and operating a car, or owning and maintaining a house. As a result, energy is often not as salient as other factors, such as households' monthly mortgage payments and rent or businesses' labor costs. The Energy Information Administration estimates that the monthly energy cost per square foot in commercial real estate is approximately $1.25. The square-foot cost to rent a commercial space nationwide is $25 per month.[6] Reducing energy costs may thus have a modest effect on the net operating income for a business, but that is a secondary or tertiary concern to the bottom line. A natural contribution from behavioral research would be to find ways to repackage energy costs so that consumers can realize the returns from investment in more efficient energy use.

Aggregating individual decisions at the national level also reveals results that are not well understood. For example, we do not know why countries vary in their energy efficiency. A common metric for measuring energy intensity is energy use (or carbon emissions) per unit of GDP per person. Energy intensity decreases with economic development. The countries with the highest GDP per capita tend to have much lower energy use per unit of GDP per person. While this insight is helpful, it also shows that different countries appear to be on different energy-efficiency curves. In Russia and China, for example, energy use per unit of GDP is much higher than in India.[7] Why are some countries more efficient in their energy use per unit of GDP than others? Understanding this phenomenon might reveal how developing countries can shift to a more efficient energy-growth trajectory. But because a transition from one curve to another likely depends on the availability of technology, a successful transition will require the willingness of developed countries to make advanced energy technologies available worldwide, perhaps including nuclear energy technologies. Such transfers are fraught with strains on international relations.

Third: Price. Global warming, pollution, and security are all external consequences or costs of the production and distribution of energy. The central thrust of social science research on global warming has focused rightly on how to adjust prices to make the market reflect the true external costs of carbon emissions. In this regard, there are four broad policy options that can help internalize the cost of carbon: namely, carbon taxes, tradable carbon emissions permits (or cap and trade), renewable portfolio standards, and minimum installed capacity requirements. Each of these approaches attempts to force the market to realize the social costs of carbon emissions, either by altering prices directly (as with a tax) or making producers and consumers of electricity and transportation fuel change their mix of inputs (as with renewable portfolio standards).

Since the late 1980s, pricing carbon has been – and ought to continue to be – the central thrust of social science research on this subject. Most technology studies of the incorporation of solar, wind, or other alternatives assume some level of carbon price,[8] and most policy studies make a suitable carbon price the centerpiece of any road map to the future or comprehensive policy proposal.[9] Creating such a pricing mechanism is, of course, a difficult matter. Markets do not emerge magically, especially markets for externalities. Their viability depends on the development of social and legal institutions, such as property rights. In the area of pollution, for example, regulations have successfully incorporated the social costs into the price of goods by imposing financial penalties on firms. Regulations also create scarcity, thereby increasing incentives to distribute the social costs more efficiently. There has been much work on how to structure such markets but relatively little research into their political feasibility, especially at the subnational level, or on how to entice businesses to participate in such markets.

Fourth: Finance. New energy projects require funding. And nearly all policy studies that lay down a road map for new energy development call for some form of targeted government investment to make up for the apparent lack of capital in a given industry. In some areas of energy, the capital costs of building a new project – such as a nuclear reactor or an integrated gasification combined cycle power plant – are too great for investors given the time to completion as well as the complexity and uncertainties associated with those technologies. In other areas, such as energy use in buildings, the energy costs are such a small fraction of the value of the economic activity that the payback to even modest capital investment is not sufficiently attractive to investors. In still other areas, such as the national power grid, it is unclear how to make money in the management of the infrastructure because of regulatory and technical uncertainty.

An essential area for innovation in the energy sector is the development of new investment instruments and financial models. Some of these instruments will take the form of guarantees against risk for projects that offer the upside of reduced carbon emissions. For example, a 2003 MIT study on the future of nuclear power argued for government-backed loans to support new power plant construction. The study contended that guarantees were necessary to draw finance back into the nuclear industry because the capital costs of constructing large, complex facilities such as nuclear power plants created huge barriers to the expansion of this power source.[10] Very little research has examined how such financial incentives are most efficiently structured, how large they must be, or how effective existing loan guarantees have been.

Another class of financial instruments consists of small or midsize funds designed to capture inefficient energy use in organizations. Many institutional users, such as hospitals, universities, and firms, set up funds that divisions within their organization can use for facility or operational improvements that have high returns in energy costs. Because the divisions themselves do not necessarily control their capital budgets or pay their energy costs, they may have little incentive to eliminate inefficiencies on their own.

The need for new funding models raises an important question: why is there insufficient capital in energy innovation? The problem may be institutional, as firms, government agencies, and other institutions may be organized in ways that eliminate incentives for people to use energy efficiently. Or the barriers may be purely economic – that is, the return on investment is too small. If the obstacles are institutional, then the challenge is identifying ways to overcome those structural impediments. If the obstacles are purely economic, then government regulations or subsidies might encourage greater investment in energy efficiency.

The prospect of government intervention raises a second key question: how effective are government subsidies, loan guarantees, and other incentives? Do government-supported financial mechanisms induce firms and consumers to make long-term investments in more efficient energy use? There is a long history of such programs in the United States and in other countries, but we know of no systematic study of their effectiveness.

Fifth: Monitoring. Any effort to regulate emissions of carbon or other greenhouse gases requires protocols for monitoring and accounting for such emissions. For the Environmental Protection Agency to enforce any carbon emissions regulations in the United States, a monitoring system at the level of individual power plants or vehicles would certainly be required. The United States has put in place such mechanisms for nitrogen oxides, sulfur oxides, particulate matter, and other airborne pollutants. Research is needed to determine both how to extend the existing monitoring system to include carbon emissions and how to design effective monitoring and accounting systems for carbon emissions regulations and taxes. Some of these issues are technical (developing sensors, for example), but others are behavioral, such as constructing a system that is trusted and that ensures compliance.

Beyond the immediate regulatory design issues lies an even bigger monitoring and enforcement challenge. A global system of emissions caps or tradable emissions permits would require a monitoring and accounting system that is transparent and that all nations trust. Such systems have been constructed for nuclear technologies and other dangerous materials. What are the lessons from those domains? Without a trusted and effective monitoring mechanism, implementing policy ideas such as cap and trade may be impossible.

Sixth: Political Will. Many of the societal changes needed to alter the ways that the United States and other countries produce and use energy will come from changes in consumer behavior, technology innovations, and corporate finance – in short, from the private sector. To tackle the climate problem, however, governments must also act. Many of the visions for an alternative energy future laid out in this volume and elsewhere assume that a carbon price will be imposed through a tax or tradable permits. There is a growing expectation that this price will be set by governments – either directly, through energy taxes, or indirectly, through regulations. There is an equally strong sense that this expectation is well ahead of public opinion on climate change.

Price offers a convenient way to see the gap between public attitudes today and the policies required to change the U.S. energy portfolio. Since the 1990s, public opinion polling in the United States and other advanced industrial economies has shown that majorities of people are "concerned" about climate change. That concern is superficial. Large majorities also express little or no willingness to pay higher electricity bills in order to reduce carbon emissions. The MIT Energy Surveys show that throughout the past decade, a majority of Americans were not willing to pay more than an additional 10 to 15 percent on their monthly electricity bill to "solve global warming."[11] Because the price of wind or nuclear power is at least 50 percent higher than the cost of coal or natural gas, we must overcome the gap in public attitudes in order to move forward. Shifting our energy mix would require a tax or carbon price that doubled the price of electricity. Such a price increase far exceeds what typical Americans today say they would support. Could such a price increase be structured so that it would enjoy the support of a majority of Americans? Would a powerful public backlash ensue regardless of which politicians championed the policy? Or do people care enough about this issue to endorse comprehensive change in energy policy?

Short of a magic-bullet technology breakthrough, a low-carbon energy portfolio will require a change in public attitudes toward energy provision in general and individual technologies in particular. Our colleagues in engineering often stress that if the public only knew the implications of current energy use, it would support aggressive policies to reduce the carbon-intensity of our economy. That is not clear to us. It is assumed that by educating people, we would raise the importance of climate in their thinking sufficiently to make them willing to pay higher energy prices. However, education might change people in other ways. As the research in the first *Dædalus* volume has showed, people underestimate the true cost of electricity from solar and wind power. Thus, public education might make alternative energies less – rather than more – popular. The effect of public education on this matter is still not understood. Would a complete and thorough education campaign alter how people think? Would such a campaign rehabilitate nuclear power as an alternative energy source? How would local attitudes about energy development affect the ability to bring on-line new energy technologies?

Beyond domestic political considerations, questions about public will in the global context loom large. In order for the level of carbon in the atmosphere to stay below 550 parts per million (ppm), the world, especially developing and emerging economies, will have to forgo a great deal of economic growth. Given China's current growth curve and its energy intensity, that nation would have to give up approximately $50 trillion in economic growth over the course of the coming century in order to keep atmospheric carbon below 550 ppm.[12] How can the advanced industrial economies ask the developing economies not to grow as quickly? Where is the political will to make a global deal that will stabilize Earth's climate?

Resolving the specific questions already on the research agenda in these six broad categories of policy activity will not be easy. Even a cursory glance at these problems confirms that unless social scientists play a central role in attacking them, successful policy development will be unlikely. However, as the articles in these two *Dædalus* volumes show, the social science disciplines that should be driving energy policy discussions are in many cases not well developed. In view of this shortcoming, how might the social science research community most effectively cut into these problems?

To address this question, we frame the agenda for social science research and public policy along two dimensions: the scope and scale of the problems being addressed. *Scope* refers to the extent of the economy implicated, with the most limited scope focusing on a specific technology (for example, a nuclear power plant); a broader scope taking into account an energy sector (at the most rudimentary level, electricity versus transportation); and the widest possible scope encompassing the entire economy. Technologies that break the barriers between sectors, such as efficient electricity or energy storage, can have economy-wide implications.

We define *scale* as the level of aggregation at which an energy problem is analyzed or addressed. The smallest scale is usually the household, firm, or power plant. A broader scale, which might include an entire city or industry, presents new opportunities for examining energy production and utilization. Households and cities both engage in monitoring and planning their activities in ways that affect energy use, but with a qualitative difference: a city's development decisions can have substantial and very long-lived consequences for large numbers of people over many decades. Even higher levels of scale are nations, with the entire globe being the highest level.

The climate challenge differs from earlier issues such as CFCs because it is of the highest scale and the widest scope. Successfully dealing with climate change requires changing the energy portfolio of the entire globe and throughout the economy. This is not to say that the challenge cannot be met. Climate change is at once more difficult and easier to address than CFCs and similar problems. It is more difficult because the scope and scale are massive. It is easier because anything accomplished in any sector can make a difference. Accordingly, we conclude that social science research should follow two paths: research designed to understand the fundamental individual and institutional changes that must ultimately take place in the transition to a new energy system; and applied research designed to make tangible progress at the local level.

Our conclusion relies on one of the great insights of the late Elinor Ostrom – that cooperation and production of collective goods, like clean water and sewer systems, can be accomplished effectively at a very local level. Those local changes can become the basis for wholesale changes on a broader scale if they can be replicated. Many of the essays in this issue point to localized (or at least relatively small-scale) changes as ways to foster the creation of less carbon-intensive energy use and production. These local efforts, if they are consistent with each other and can be linked, may produce cumulative changes in energy use or may cause energy technologies to evolve more rapidly.

Activity at this manageable scope and scale is already under way. Social scientists have begun to engage with the energy problem in new ways. Increasingly, as engineers and scientists tackle the problem of technology development at sufficient scope and scale, social scientists are working with them to study energy at the level of large cities and states. Projects in Tokyo, London, Toronto, and New York are mapping and monitoring energy use at the scale of large cities. New York University's Center for Urban Science and Progress (CUSP), working with the Office of the Mayor, is developing a massive "living lab" in Brooklyn to measure how people use energy in their daily lives, to experiment with ways of altering behavior, and to examine how to implement new technologies that can significantly lessen the energy intensity of economic activity.

At the state level, California is implementing Assembly Bill 32, which would cut the state's greenhouse gas emissions to 1990 levels by 2020, and the state (among others) has long had a Renewable Portfolio Standard. The New England states created an emissions trading system, called the Regional Greenhouse Gas Initiative, that is designed to reduce CO_2 emissions in the power sectors by 10 percent in Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont by 2018. The California and New England experiments are in their nascence, but these initial attempts to create markets for carbon are instructive about how to create effective trading markets for carbon as well as how to assess the effectiveness of such markets compared with taxes, renewable portfolio standards, and other ways of reducing greenhouse gas emissions.

Perhaps the most telling feature of all these attempts to alter energy use is their scale. These are not experiments conducted in small labs in a university setting. Rather, they are efforts to use entire cities and states as test beds in which to solve the problems of modifying behavior; monitoring energy use; changing public attitudes; financing energy innovations; and understanding in concrete terms the consequences, costs, and risks of our actions. Doing that requires stepping out of the traditional lab setting and observing society on a relatively large scale.

Each of these cases provides examples of collaborative efforts between technologists and social scientists to address the energy challenge head-on and with concrete research. What is needed today is evidence of what works and what does not; which technologies can be brought to scale and which cannot; and which institutional arrangements work in a given legal, political, or cultural context and which do not.

At the same time, research is needed to understand the fundamental societal changes required for solving the climate problem. A good example is research into pricing greenhouse gas emissions. While it is unlikely that a global pricing scheme will come into being anytime soon, the important research on structuring national and international markets for pricing and regulating carbon must continue as a central activity of the social science research agenda. Ultimately, some form of greenhouse gas pricing will likely be needed; thus, understanding how to design a workable system is essential.

But the design of pricing mechanisms and markets will address only some of the issues involved in transitioning from a heavily coal-based electricity sector and oil-based transportation sector to a less-carbon-intensive energy portfolio. This volume has identified other issues that, like a pricing mechanism, need research now to ensure the development of tools that future policy issues will require. These issues include the design of international agreements, the creation of durable yet adaptable policies, the shaping of public opinion, and the institutional changes that will inevitably accompany a new energy system.

In short, the social science research agenda requires a combination of real-world experiments designed to take positive steps at modest scale and scope along with more fundamental research into the institutional and political changes that will ultimately allow climate and energy policy to operate economy-wide and at a global scale.

ENDNOTES

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Acknowledgments: We have benefited from conversations and interviews with many colleagues, including all the authors in this volume and the Spring 2012 issue of *Dædalus*. We would like to acknowledge the very helpful comments of Michael Greenstone, Rebecca Henderson, Steven Koonin, and members of the American Academy's Alternative Energy Future project.

1 James Gustave Speth, *Red Sky at Morning: America and the Crisis of the Global Environment* (New Haven, Conn.: Yale University Press, 2004), 95.

2 Mario Molina and Durwood Zaelke, "A Climate Success Story to Build On," *The New York Times*, September 26, 2012, http://www.nytimes.com/2012/09/26/opinion/montreal-protocol-a-climate-success-story-to-build-on.html.

3 Molina made this observation in a presentation delivered at the 1998 MIT Congressional Staff Seminar sponsored by the Alfred P. Sloan Foundation.

4 Nicholas Stern, *The Economics of Climate Change: The Stern Review* (Cambridge and New York: Cambridge University Press, 2007).

5 Adam Jaffe and Robert Stavins, "The Energy Efficiency Gap," *Energy Policy* 22 (1994): 804–810.

6 Christina S.N. Lewis, "Rents Signal Rise of D.C., Fall of N.Y.," *The Wall Street Journal*, January 8, 2010, http://online.wsj.com/article/SB126291211587420679.html.

7 *BP Energy Outlook to* 2030 (London: BP, January 2012), http://www.bp.com/energyoutlook.

8 For instance, see Richard Lester and David Hart, *Unlocking Energy Innovation* (Cambridge, Mass.: MIT Press, 2012).

9 See, for example, Stern, *The Economics of Climate Change*.

10 *The Future of Nuclear Power: An Interdisciplinary MIT Study* (Cambridge, Mass.: Massachusetts Institute of Technology, 2003).

11 In 2002, as part of the MIT study *The Future of Nuclear Power*, the first MIT Energy Survey examined public attitudes toward a range of sources of electric power. The study was repeated in 2007 with the addition of questions about global warming.

12 Michael Greenstone provided this calculation in a personal communication from September 17, 2012.