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Resources

RESOURCES FOR THE FUTURE

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Cover photo: Efforts to control the destructive Japanese beetle, first found in the United States in 1916, are estimated to cost the country more than $460 million a year.
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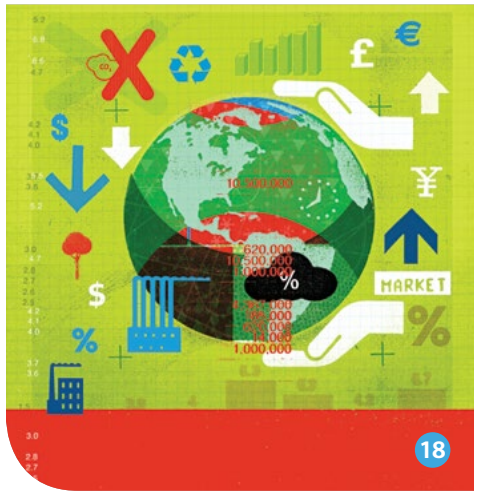

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In This Issue

Burtraw

Dallas Burtraw is the Darius Gaskins Senior Fellow at RFF, an associate director of the RFF Center for Climate and Electricity Policy, and one of the nation's foremost experts on environmental regulation in the electricity sector. He is particularly interested in incentive-based approaches for environmental regulation and recently has studied ways to introduce greater cost-effectiveness into regulation under the Clean Air Act.

Crane

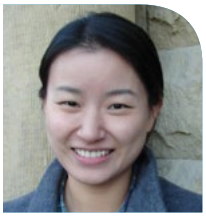
Chris Crane is the president and chief executive officer of Exelon Corporation, where he oversees a family of companies representing every stage of the energy value chain, with approximately 35,000 megawatts of owned generating capacity and 7.8 million electric and natural gas customers in Illinois, Maryland, and Pennsylvania.

Engle

Robert Engle, the Michael Armellino Professor of Finance at New York University's (NYU) Stern School of Business, was awarded the 2003 Nobel Prize in Economic Sciences for his research on the concept of autoregressive conditional heteroskedasticity. He is the director of the NYU Stern Volatility Institute and a cofounding president of the Society for Financial Econometrics.

Epanchin-Niell

RFF Fellow **Rebecca Epanchin-Niell**'s research focuses on ecosystem management, particularly understanding how human behavior affects ecological resources and identifying strategies to improve management. Much of her work has focused on invasive species, including strategies to control established invaders, improvement of monitoring strategies, and cooperative management.



Kim

Nuri Kim is a postdoctoral research fellow in the Department of Communication at Stanford University. Her current research includes minority issues in small group communication, the role of emotion in political processes, and survey methodology.

Krosnick

RFF University Fellow **Jon A. Krosnick** is the Frederic O. Glover Professor in Humanities and Social Sciences and director of the Political Psychology Research Group and the Summer Institute in Political Psychology at Stanford University. He is a social psychologist who does research on attitude formation, change, and effects; the psychology of political behavior; and survey research methods.

Krupnick

Linn

MacInnis

McConnell

Newell

Siikamäki

Alan J. Krupnick is the director of the RFF Center for Energy Economics and Policy and a senior fellow at RFF. His research focuses on analyzing environmental and energy issues, in particular, the benefits, costs, and design of pollution and energy policies, both in the United States and in developing countries.

Joshua Linn is an RFF fellow and associate director of the Center for Climate and Electricity Policy. His research addresses the effects of environmental regulation and market incentives on technology, with particular focus on the electricity sector and markets for new vehicles.

Bo MacInnis is a visiting scholar in the Department of Communication at Stanford University, a research investigator at the University of Michigan Population Studies Center, and a pilot scholar at the Michigan Center for Urban American Aging Research. Her research focuses on climate change and survey research methods.

RFF Senior Fellow **Virginia McConnell** works on environmental issues related to air pollution and urban transportation. Her recent focus has been on the link between urban growth and the environment. Specifically, she is evaluating policies to reduce vehicle pollution, programs to scrap old cars, inspection and maintenance programs, and emissions taxes.

RFF Board Member **Richard Newell** is the director of the Duke University Energy Initiative and the Gendell Professor of Energy and Environmental Economics at the Nicholas School of the Environment. In 2009, he was confirmed by the Senate as the head of the US Energy Information Administration, where he served until 2011. He has published widely on the economics of markets and policies for energy, the environment, and related technologies.

Juha Siikamäki is an associate research director and fellow at RFF. His recent work has examined nature recreation in the United States, the potential for improving the cost-effectiveness of biodiversity conservation, valuation of ecological benefits from reduced air pollution, and evaluation of households' preferences for energy efficiency.

On the Bumpy Road to US Climate Action

In 2009, the House of Representatives made a clear policy choice in its drive to cut carbon dioxide emissions: put a price on carbon by means of a cap-and-trade system and preempt the US Environmental Protection Agency's (EPA) authority to regulate those emissions, as proposed in the narrowly approved Waxman-Markey bill.

Ironically, it was a Democrat-controlled House that adopted this market-based approach—albeit making it horrendously complex—which was originally promoted by President Bush for addressing acid rain in 1990. Meanwhile, many Republican leaders in 2009 totally rejected it for addressing greenhouse gases, and the bill was not brought to a vote in the Senate.

Given Congress's failure to "price" carbon, EPA is exercising its authority to address the problem under the Clean Air Act. President Obama is leading the charge, but EPA has been facing lawsuits requiring it to act even if he were not so inclined.

EPA, in its recently proposed Clean Power Plan for existing power plants, took a number of unusual steps. Its outreach to stakeholders before and after the rule was crafted has exceeded any previous efforts. It has set separate carbon dioxide reduction targets for each state, given states considerable latitude in their options for compliance, and encouraged states to create joint plans.

In the months ahead, EPA will examine the millions of public comments it will undoubtedly receive, with the possibility of significant changes in the final rule due next June.

For more than a decade, RFF scholars have analyzed various policy options, including cap and trade, a carbon tax, a clean energy standard, and EPA regulation. They have provided technical help to the Regional Greenhouse Gas Initiative, California's carbon market, Europe's carbon market, and now China's pilot carbon dioxide cap-and-trade projects.

EPA's Clean Power Plan is receiving considerable attention from experts within the RFF Center for Climate and Electricity Policy. Dallas Burtraw and Nathan Richardson already have produced a number of useful insights—for instance, showing how the plan might cost-effectively achieve emissions reductions within striking distance of the US Copenhagen pledge. And in the infographic on pages 6–7, RFF's Anthony Paul and Sophie Pan break down the four building block components that together form EPA's "best system" for meeting state targets. Ahead will be more research and a number of public events to elucidate the issues.

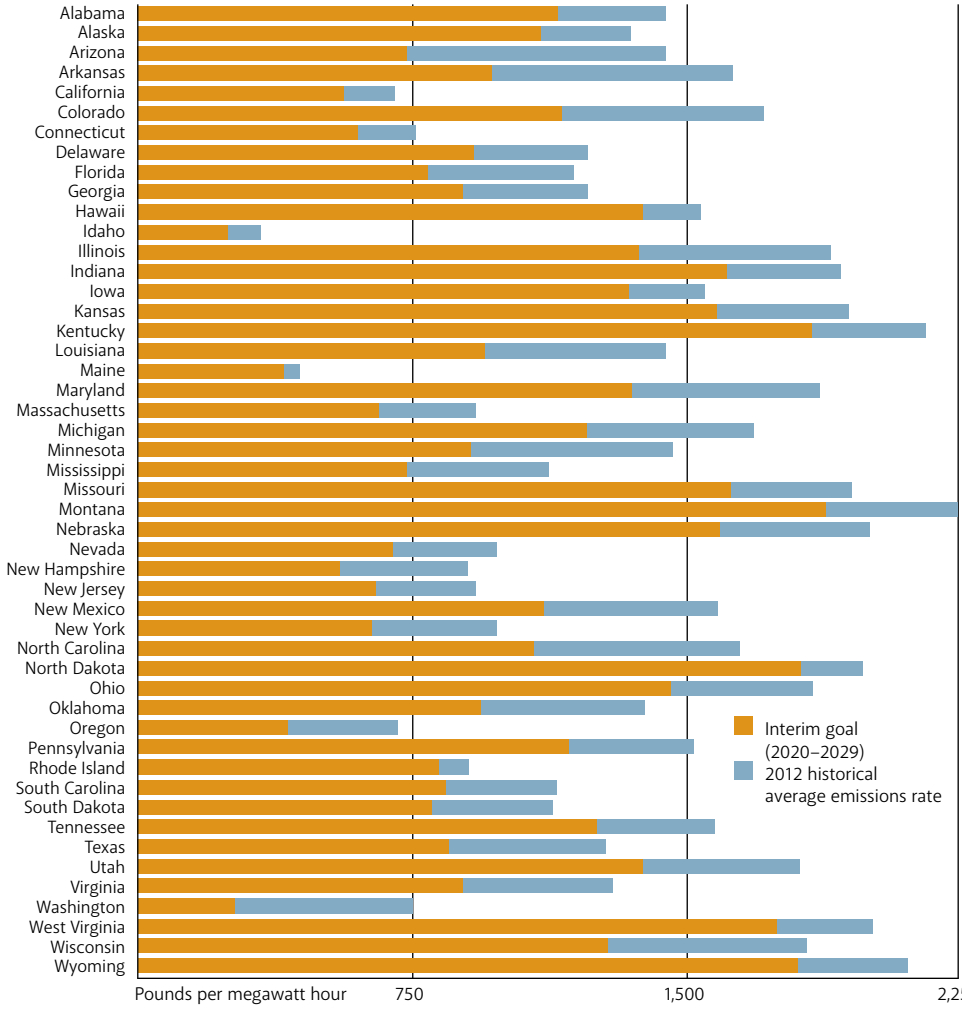
Given the scope of the challenge, regulation is just one of many tools that are likely to play a role in addressing climate change. A carbon tax conceivably could arise as an option at the national level in conjunction with broader tax reform. And at the state level, such a tax could become a compliance option under EPA's rule. RFF researchers continue to consider a carbon tax as the debate unfolds.

Phil Sharp, President
sharp@rff.org

EPA's Clean Power Plan: Breaking Down the Building Blocks

In June, the US Environmental Protection Agency (EPA) announced a proposed rule for reducing carbon dioxide emissions from existing power plants. Using its authority under the Clean Air Act, EPA set state-specific targets for emissions rates reductions (Figure 1). However, many questioned how this proposed plan would impact actual emissions from the electricity sector and how these reductions could be achieved.

Figure 1. EPA Clean Power Plan Emissions Rate Reduction Targets

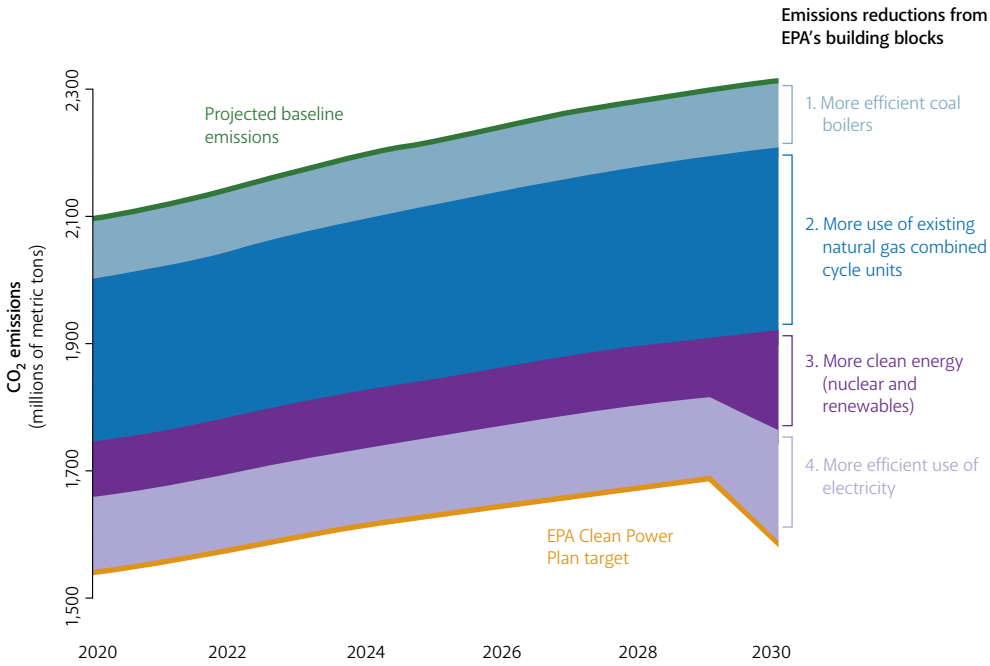


Source: US Environmental Protection Agency, Office of Air and Radiation. 2014. Goal Computation Technical Support Document, Appendices 3 and 5. Washington, DC.

In new analysis, RFF's Anthony Paul and Sophie Pan estimated actual carbon dioxide emissions reductions by converting the proposed targets from emissions rates to tons of emissions (Figure 2). EPA gives states the option to convert their rate targets into mass (tons) targets, and their choices will be consequential. If a state adopts a rate target, the amount of carbon emitted will depend on how much electricity is produced. Power generation would increase with brisk economic growth or an influx of electric vehicles, and corresponding emissions would increase even while still complying with the rate target. A mass-based target would ensure a consistent emissions outcome, but states and utilities would have to find ways to reduce emissions more if power generation increases.

EPA also selected four "building blocks" as the "best system of emissions reduction" for states to meet their targets (Figure 2). But which building blocks will survive legal challenge? Figure 2 shows possible futures for emissions reductions if any of the building blocks fall. If just building block #1 survives, only the emissions reductions represented in light blue in Figure 2 will be made, and EPA will lose the opportunity to make meaningful reductions in emissions across the sector.

Figure 2. Possible Futures for CO_2 Emissions from the US Electricity Sector
How EPA's building blocks stack up



Source: Based on the Energy Information Agency's Annual Energy Outlook 2014 Reference Case projection of electricity production. See more at http://common-resources.org/2014/epas-building-blocks/.

Highlights from Events at RFF

Natural Resources, Ecology, and Public Policy: Time for Some Unconventional Ideas?

www.rff.org/unconventional

"If productivity can increase and we can produce enough food by 2050, after that . . . we won't need more food. So what are we going to do with all of that extra productivity? For the very first time in human history, we can take those productivity gains and actually decrease the amount of land [we use]."

Jack Bobo, senior advisor for biotechnology, US Department of State, on basing agricultural planning on future demographic trends. May 28, 2014.

Making Sense of EPA's Proposed Rule for Reducing Greenhouse Gas Emissions from Existing Power Plants

www.rff.org/existingpowerplants

"Our goal throughout this—and we talked a lot to stakeholders—was to ensure that we continued to maintain an efficient, affordable, and reliable energy system, and you'll see that the flexibility provided in this rule will help us achieve that."

Reid Harvey, director, Clean Air Markets Division, Office of Atmospheric Programs, US Environmental Protection Agency, on the considerations involved in the development of the Clean Power Plan. June 5, 2014.

Considering the Contributions of Forests in the Management of Greenhouse Gas Emissions

www.rff.org/forestmanagement

"We're finding many ways to use [Forest Inventory and Analysis Program] data and expertise to help us at least answer big questions—not just about carbon but also about carbon and its relation to other ecosystem services. That's where I think the policy issues are going to be."

David A. Cleaves, climate change advisor to the chief, US Forest Service, on the range of applications for forestry data. January 29, 2014.

Exploring the Local Impacts of Shale Gas Development

www.rff.org/localimpacts

"We do find evidence that accident rates and the severity of accidents are increasing in the same county where shale gas development is occurring. These are costly by themselves but also have impacts on emergency medical services and the rehabilitation of injured individuals. Understanding these costs could direct resources toward prevention."

Lucija Muehlenbachs, assistant professor, University of Calgary, and visiting fellow, RFF, on the effects of shale development on local transportation safety. April 10, 2014.

Limits to Securitization: The Future of Insurance

www.rff.org/futureofinsurance

"Instead of taking all these risks and concentrating them in a handful of large reinsurers or insurance companies, you can actually turn these risks into securities and have pension funds invest in them."

Peter Nakada, managing director of risk markets, Risk Management Solutions, Inc., on innovative ways to manage risks that are difficult to insure. June 4, 2014.

Left to right, from top: Jack Bobo (with Molly Macauley and Joel Darmstadter), Reid Harvey, David A. Cleaves, Lucija Muehlenbachs, Peter Nakada (with Bob Litterman), and Fran Ulmer

From the Gulf to the Arctic: What Have We Learned Since the *Deepwater Horizon* Spill?

www.rff.org/gulftoarctic

"The Arctic is an ocean surrounded by land. It's an important distinction from the Antarctic, which is land surrounded by water. And although it's an international space because it is surrounded by eight countries, it's also very much a national space where countries have their own hopes, dreams, economies, and regulatory regimes. It's a complicated place."

Fran Ulmer, chair, US Arctic Research Commission, and member, National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, on understanding the inherent challenges of Arctic development. April 17, 2014.

Resources available online: presentation video

Saving Europe's Key Weapon against Climate Change

Climate change is widely regarded as the greatest threat to the global environment. But the centerpiece of the European Union's climate policy is being hobbled.

That centerpiece is the cap-and-trade Emissions Trading System (ETS), under which companies buy and sell carbon-reduction credits. The cause of the problems plaguing the European market is the presence of a two-gigaton surplus of emissions allowances. The oversupply is the result of a number of factors, including the economic downturn, the influence of carbon taxes and other complementary policies in several member states, an influx of certified reduction credits from international offsets, the banking of allowance leftovers, and the early auctioning of next-phase allowances.

The surplus has created a problematic decline in the price of emissions allowances, which dropped as low as €2.81 in April 2013. Through the fall of 2013, prices hovered near €5, recovering somewhat to near €7 in early 2014. While low prices are generally good news, these are an order of magnitude lower than the estimated €32 to €63 needed to motivate investments necessary to achieve the European Union's emissions reduction target.

If this situation looks familiar to some market followers, it's because almost every previous cap-and-trade program has overestimated the costs faced by firms, causing initially high prices to fall.

What can be done? Solutions often suggested include revising emissions targets or retiring allowances. But these options would introduce new information and change the balance of supply and demand in the market, creating uncertainty for investors eyeing future price trends. For that reason, while initially intuitively appealing, they tend to fall from favor.

Another option exists to save the European climate emissions reduction market, and I believe it deserves more attention: the adoption of a price floor.

> A price floor could prove to be an efficient fix for the European Union's current Emissions Trading System surplus problems.

A price floor easily could be enforced by introducing a minimum price in allowance auctions. When a market's price dips below the price floor, a portion of allowances is held back from being sold; this restricts supply and supports healthier, more stable market prices. That is part of the reason that a price floor is generally considered an important feature of good auction design. In fact, as my son pointed out to me, this is the same mechanism that one sees on eBay, where a seller can introduce a minimum price for bids that will be considered.

Detractors of the price floor idea have mischaracterized it as a tax, but it is certainly not a tax. A large portion of emissions

allowances in the EU trading system are still given away for free, and they would not be affected. In fact, recipients of those allowances would benefit from the price support for the value of the allowances as an asset in the market.

One of the biggest benefits of a price floor is its nondiscretionary and rule-based approach, which helps markets to better anticipate future changes. Because it can automatically adjust the strictness of its parameters without waiting for administrative action, a price floor offers more transparency than many alternatives. The mechanism also encourages participants to invest in low-emitting technologies by ensuring the minimum value of emissions reductions. It potentially supports the recirculation of auction revenue toward research and development or innovative investments while mitigating the impact of interference from complementary policies.

The European Commission is considering the adoption of a policy that is in some respects similar to a price floor—and that is commendable. However, the system also is more administratively complicated without corresponding benefits.

The proposal is for a price stability reserve that would be triggered by the liquidity in the market. Each year, regulators would look back two years to observe the difference between allowances that have been issued and those that have been surrendered to cover emissions. The difference constitutes the allowance bank. If that bank grows above a maximum amount, a portion of the allowances to be introduced to the market in the current year would not be made available, and they would be added to a reserve. Otherwise, if the bank falls below a minimum amount, additional allowances would be drawn from the reserve and added to the market. The allowances would not ever leave the market, but their availability would be made flexible to adjust the liquidity, with the hope that this will influence the allowance price path.

The greater complexity, in my view, should cause immediate reservations. Any trading program for a government-created intangible asset such as emissions allowances must be as transparent as possible if it is to garner the public acceptance and support necessary for success.

The better approach would be the simple price floor. Both policies would bolster prices and reduce variations in allowance values, but a price floor could prove to be a more efficient fix for the European Union's current ETS surplus problems because it will lead to more predictable and cost-effective outcomes—and greater public understanding, acceptance, participation, and support. ● —Dallas Burtraw

Greening the Global Economy: Roles for Business and Government

An Interview with Linda Fisher

With a career that has taken her to the top levels of the US Environmental Protection Agency (EPA) and the global company DuPont, RFF Board Member Linda Fisher has worked to progress corporate environmental performance from within and without. *Resources* recently sat down with Fisher, currently the vice president of DuPont Safety, Health, and Environment and the company's chief sustainability officer, to explore business and government perspectives on some of the major environmental issues of our time.

RESOURCES: How has your time in government influenced how you approach your current job at DuPont?

LINDA FISHER: I would say it's influenced me in three significant ways. Probably the most obvious is that I have a very keen appreciation of why people at EPA make the decisions they do. I understand the flexibility or inflexibility of the laws and regulations they have to administer and make decisions by. I understand the resource challenges, public pressure, and public perceptions that influence how they might approach public policy issues—or a company like DuPont. This helps me think through how DuPont can best engage and interact with the agency.

Second, because EPA is a government agency, by definition I had to listen carefully to the opinions and information people bring from all sides of an issue. That includes other government agencies, Congress, the NGO community, and a whole range of civil society that has a stake in decisionmaking. I have been able to bring a sensitivity to all those perspectives into DuPont, engaging the company to reach out to constituencies it otherwise might not have realized were important.

A third influence from my time in government is that I have a strong sense of how a company like DuPont can innovate to bring market solutions to the environmental challenges that EPA is grappling with.

RESOURCES: What are some of these innovations, and what business opportunities does DuPont see in the future green economy, if you envision one?

FISHER: The green economy offers huge opportunities for science and innovation-based companies. If you are investing as an industry in new, disruptive technologies, then a carbon-constrained world or a green economy creates the opportunity to grow businesses that might not have been envisioned just a few years ago. But greening the economy does not necessarily offer growth opportunities for companies that are not investing in innovation. This difference in approaches

helps explain the tension in how corporate America views green energy, carbon pricing, and other environmental innovations and regulations.

At DuPont, where we pride ourselves on our science and innovation, we see green energy as an opportunity. We are investing in advanced biofuels, improved longevity and efficiency of solar technology, and reduced use of petroleum through improved energy efficiency, to name a few areas.

RESOURCES: The push for a greener economy is being driven by not just regulatory strategies in the United States but markets all across the world. How has being a global company affected DuPont's environmental strategies?

FISHER: We are tracking what I will call "sustainability trends." For instance, what are the issues and pressures around water in the countries in which we want to operate? What are the pushes for energy efficiency or more regulation around toxic substances in the past several years? What are the changing trends in product regulation? Many trends have not hit in the United States yet or are hitting in fits and starts—for example, the push for zero waste to landfills. DuPont's sustainability, product regulatory, and product stewardship teams are the eyes and ears for these kinds of practices, and they bring them back and work with our businesses on them.

We also track regulation as it evolves globally. Around the world, many governments are talking about strict regulation of different technologies, but the question is, when will they act? What will the regulations look like?

DuPont is feeling more market pressure around some of the sustainability metrics, such as the greenhouse gas footprint of our manufacturing process and our water use. We are constantly surveyed by hundreds of companies for the absence or presence of certain chemicals in our products. These are pressures—beyond just regulation—that we face as a corporate producer and seller of goods into the global marketplace.

RESOURCES: How does the role of a strong regulatory backstop compare to these other forces that may promote strong environmental performance? Is it realistic to expect the private sector to take environmental performance into account without regulatory prompting? As you know, there has been a lot of talk of corporations taking the lead in environmental performance and maybe even getting out ahead of government.

FISHER: One is not a substitute for the other; both are important. I have said frequently that the private sector cannot make up for the absence or the failure of sound government policy. But what the private sector is doing is meaningful and should not be ignored.

Is the private sector out ahead of the government? It depends on what government and in what way. I would say that in many instances, the private sector is

> If you are investing as an industry in new, disruptive technologies, then a carbon-constrained world creates the opportunity to grow businesses that might not have been envisioned just a few years ago.

moving ahead to develop technical solutions to environmental problems.

At DuPont, that means we are investing to improve solar cells, for example, to drive their prices down and make them achieve grid parity sooner. We are doing that in the face of what I will call "uneven" government policy globally pushing for solar energy.

More broadly, many in industry are trying to improve their own energy efficiency and bring products to market that will improve the energy efficiency of their value chain. Government policy and energy pricing are part of the driving force for this shift.

Would uniform policies help? Yes. Would a carbon regulatory regimen help? Yes, that's why DuPont was one of the founding members of the US Climate Action Partnership, calling on the federal government to enact regulation to reduce greenhouse gas emissions. It's not as though 100 percent of industry is playing from a competitive point of view; regulation is important.

RESOURCES: What do you think are the best opportunities for reforming US environmental policy?

FISHER: Much of environmental policy was developed to prevent harm by preventing pollution, and it has been successful and needs to be there. I think the next question is how to use environmental policy coupled with energy or agricultural policy to induce the innovation needed to solve the growing world's demand.

Partly, we as a leading nation need some kind of climate legislation to drive more consistent long-term greenhouse gas reductions and foster more aggressive adoption of new technologies. We have not begun to really think about how we are going to deal with water. Another issue is food—how are we going to produce enough food in a sustainable way to feed the world?

If you look at agriculture, EPA has jurisdiction over water quality and pesticides. That jurisdiction is important, but it doesn't provide the answers for how we're going to nutritionally feed a growing population globally.

So looking at the mega-challenges of our time, how do you get the agencies to think beyond protecting citizens of the world from certain pollutants, which is important, but then to foster solutions to the food security, energy, water, and transportation needs? I would like to see the government play a more active role, but in a sense, it is beyond its statutory mandate today, and that is a challenge. ●

Can Product Labels Nudge Energy Efficient Behavior?

Richard Newell and Juha Siikamäki

To minimize costs, consumers looking to purchase a new appliance should give equal weight to the purchase price and the discounted operating cost over the appliance lifetime—that is, they should be willing to pay $1 in increased purchase cost for each dollar of reduced lifetime operating cost of the appliance. But many experts argue that in reality, consumers undervalue energy savings. This results in the classic energy efficiency gap—consumers are reluctant to adopt energy efficiency investments that could save them money down the road.

One possible reason is that understanding the operating cost can be a challenge that involves calculating the daily kilowatt-hour consumption rates of appliances to estimate annual costs and energy consumption per year. To streamline this process, appliance manufacturers are required to provide information about the operating costs of major household appliances through labeling programs, such as EnergyGuide. But do these labels actually encourage energy efficient purchases? And what label features most effectively encourage investment in energy efficiency?

In an experimental study to examine these questions, we evaluated the effectiveness of different energy efficiency labels in guiding households' energy efficiency decisions. We surveyed 1,248 households and used randomized treatments with alternative energy efficiency labels to see how the label and the information it contains affects households' willingness to pay for energy efficiency. The labels in Figure 1 on page 16 represent an illustrative subset of the labeling treatments used in the experiment. We sampled respondents who are the owners of single-family homes and asked them to make choices about purchasing a central household water heater.

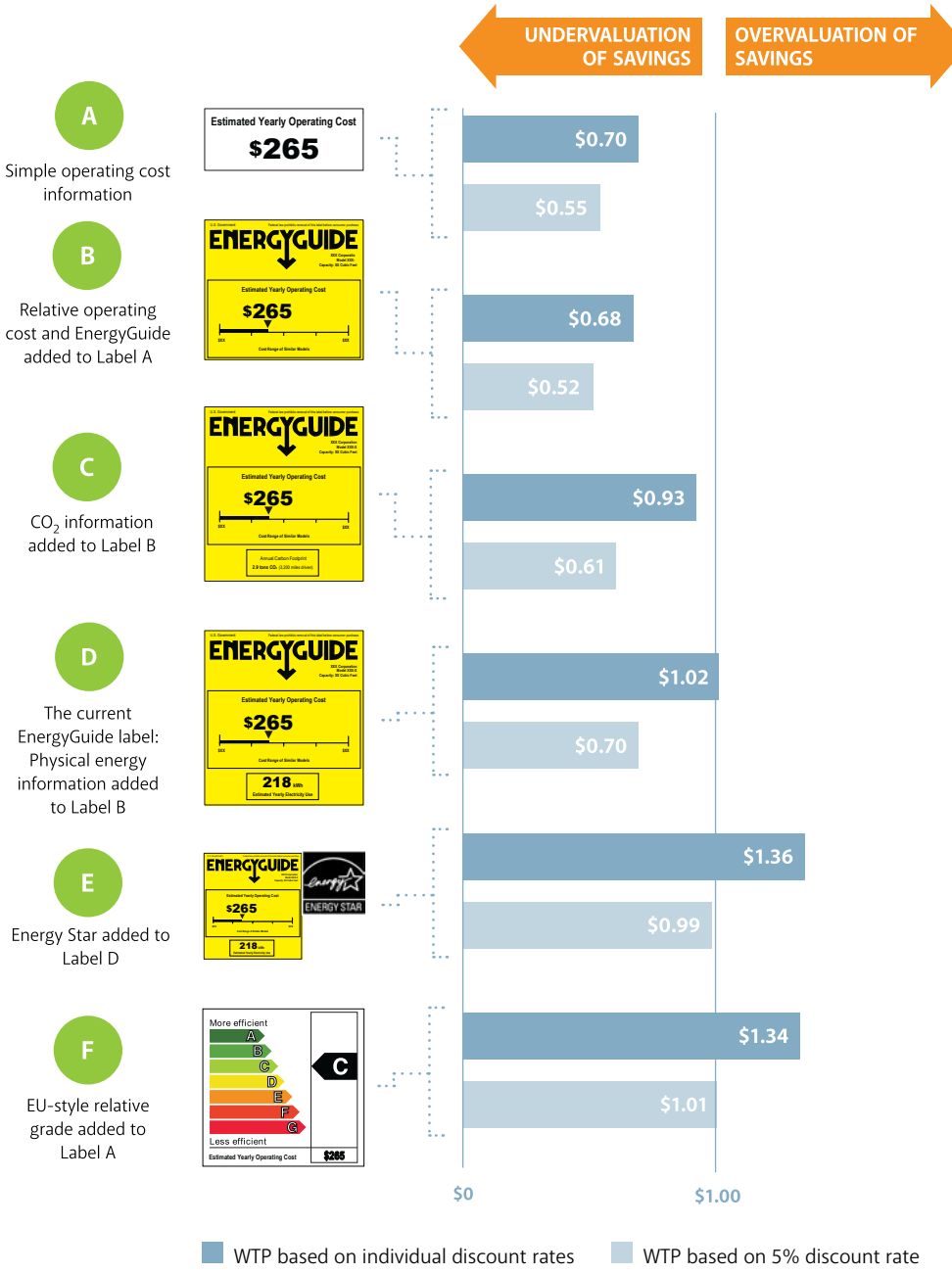
We found that providing simple information on the cost of operating the appliance was the most important element for encouraging investments in energy efficiency. Information on physical energy use and carbon dioxide (CO_2) emissions has additional but lesser importance. And labels that endorse or grade appliance models have a substantial impact on encouraging choices with higher energy efficiency, potentially even beyond what makes economic sense.

Energy Efficiency Labels

The current EnergyGuide label (Figure 1, Label D) provides the baseline for most of the treatments we administered. Our experimental approach involves evaluat-

Figure 1. Relative Willingness to Pay (WTP) for Energy Savings

Amount survey respondents are willing to pay for $1 of reduced lifetime operating costs



Source: Newell and Siikamäki (forthcoming).

ing both the information content and the style of representing the information on the label. We evaluated the use of economic information, physical information on energy use and CO_2 emissions, a letter grade indicating efficiency rank, the Energy Star logo, as well as the inclusion or exclusion of the range of energy costs of other, similar appliance options in the market. To evaluate the effectiveness of these attributes, we fielded multiple treatments, which either included or excluded the above information content, to enable us to empirically identify the effect of a specific piece of information.

Paying for Purchase Cost versus Operating Cost

Figure 1 summarizes the estimated willingness to pay for reduced operating cost, based on the six different labeling treatments.

For a decision to be cost-minimizing, $1 should be worth $1 whether it is paid for buying a product or operating it. In contrast, a value less than $1 indicates relative undervaluation of energy savings, while a value greater than $1 represents overvaluation of energy savings. A complicating factor, however, is that operating costs occur in the future, so we must account for the time value of money by discounting operating costs to compare them to the purchase cost.

We find that the degree to which different labels guide households toward accurate valuation of energy savings depends importantly on the discount rate assumed for the analysis. To examine this, we estimated the effects of different labels using two alternative discount rates: individual-specific discount rates elicited in the experiment and a 5 percent rate typical of regulatory analysis.

Information labeling treatment A includes only simple operating cost information. It yields an estimated mean willingness to pay for discounted operating cost savings of $0.70 when employing individual discount rates—which have a mean value of 11 percent—and $0.55 when using a 5 percent rate. Although this suggests a significant undervaluation of energy efficiency, it also indicates how potent even the most basic information can be. Adding information on the relative operating cost range of comparable models and the yellow EnergyGuide image (Label B) does not add to the basic information value already given by Label A.

Adding CO_2 emissions information in Label C provides a boost to the relative value of energy savings but is not as important as the direct monetary value of energy cost reductions. Label D—the current EnergyGuide label—leads to a willingness to pay $1.02 for $1 in energy cost reductions when individual discount rates are used. But if one questions the relatively high individual discount rates and instead uses a 5 percent rate, Label D is associated with choices that undervalue energy savings by about 30 percent.

Adding the Energy Star endorsement (Label E), which is approved for display on high-efficiency product models by the US Environmental Protection Agency, significantly raises the value placed on energy efficiency. Similarly, Label F—which bears a European Union–style energy efficiency letter grade—shows how even a relatively simple indication of energy operating cost has a powerful effect. Label E and F suggest roughly cost-minimizing behavior using a 5 percent discount rate and about 35 percent overvaluation of energy savings using individual discount rates.

FURTHER READING

Newell, Richard A., and Juha V. Siikamäki. Forthcoming. Nudging Energy Efficiency Behavior: The Role of Information Labels. Discussion paper 13-17REV. Washington, DC: RFF.

A FINANCIAL APPROACH
to Environmental Risk

Robert Engle

When we talk about risk in the financial world, we are typically referring to an asset or portfolio whose price may decrease down the road. Even though risk implies a level of uncertainty, we are able to model and measure the risks associated with these assets. One of the typical ways we do this is to assess their volatility; if their prices change often, we would argue that you take on a large risk by holding them.

When volatility is especially low, it is very likely to rise again. But before the financial crisis, the risk management tools that we generally used did not offer an easy way to measure this potential and warn people in the financial sector that these risks could change.

Since then, we have built volatility models that allow us to project how fast risks can change, using historical data to simulate a number of future sample paths for long-run risks. These tools now allow us to look back on the period of time before the financial crisis to understand why everything went wrong when it seemed to be going well. In fact, just before the crisis began, only short-term volatility was low; in the long run it was high, significantly changing the situation's perceived long-run risks.

Risks considered "long-term" are sufficiently far in the future that what we see today only has a tiny bearing on what the long-run risk really is and include events such as economic recessions, inflation, terrorism, war, and even climate change.

Climate Change as a Long-Term Risk

So why do we think of climate change in the long-run risk category? The scientific evidence is clear that the climate is changing. However, we are not sure what the economic costs associated with this change will be or what the economic benefits would be of doing something about it. The topic of climate change includes large uncertainties that we have to address as aspects of long-run risk, but the financial community is in the business of making decisions under uncertainty. Knowing this, how should this community approach climate uncertainties?

A good initial approach is to assess the potential financial impacts of climate change. We assume that the global economy will be able to produce fewer goods and services as climate change progresses than it would without climate change. We also assume that the government will have to take a number of actions, such as building dikes or moving power plants, and that funding these actions will require raising taxes and will increase the cost of doing business for companies. Costs from doing so may be significant, but they are far in the future and uncertain as of now. Revealing more information on these costs requires projecting and comparing a variety of long-run risk scenarios for the stocks or assets in question.

If you think about the whole of the market as being one large, risky asset that faces a long-run climate change risk, then we would expect today's stock market to drop if future climate risks were seen

If we are effective at responding to climate change, the stock market should reward us today for taking steps to reduce long-term risk in the future.

as more severe. Conversely, we could expect today's stock market to go up if future climate risks were thought to be less severe. Assuming these hold true, we wouldn't have to wait 50 years or so to find out whether we've had a positive impact on the environment and would instead see the stock market respond today. If we are effective at responding to climate change, the stock market should reward us today for taking these steps to reduce long-term risk in the future.

Hedging against Climate Change

Now that we've identified climate change as a long-run risk, how can we hedge against it? I have described the market as one large and risky asset, but in reality it's composed of a large number of assets in which we can choose to invest—some of which will be more sensitive to long-run risk than others. We might have one portfolio in the short run, but if the long run changes, we want to be prepared for that with a second, hedge portfolio.

What features define a hedge portfolio? First, it should be expected to outperform in a crisis. In other words, it should have especially high returns during a crisis but will underperform on average because it is composed of essentially inferior assets with special benefits only under specific circumstances.

Another feature is that when volatility goes up, we might expect that these assets would become more valuable. In other words, the volatility and returns would be positively correlated instead of negatively correlated the way they are for most assets. This is because when the volatility goes up, investors need the hedge even more and demand rises.

Taking these features into account, what assets would we pursue when building a portfolio to hedge the effects of climate change? We would start by looking for companies that are expected to do well in a high-cost but low-use carbon environment. This could include alternative energy strategies, non-carbon transportation and manufacturing solutions, sequestration technologies, and so forth.

These environmental stocks are, on average, viewed as underperforming, and that in itself is an important observation. It means that people are willing to pay more for them because they're hedging an environmental long-run risk. If we believe that investors are, in fact, concerned and willing to price environmental risk, then we also can assume that the stock market would rise in response to a reduction in risk. Any president who can reduce environmental risk should see a boom in the stock market.

I propose that we use a carbon tax to reduce Social Security payroll taxes, helping to offset the regressive nature of the tax.

The Role of a Carbon Tax

This suggests that implementing some kind of comprehensive carbon tax and using its revenue to reduce other taxes would reduce risk and increase the stock market. While this measure theoretically should fly through Congress with the support of voters and investors, the reality is that political and special interests make this an unlikely scenario without a little bit of fine-tuning.

I propose that we use a carbon tax to reduce Social Security payroll taxes, helping to offset the regressive nature of the

RFF President Phil Sharp sits down with Robert Engle at the March 18 Nobel Laureate Lecture, "A Financial Approach to Environmental Risk."

tax. Today's under-40 voters could be big supporters of this measure, which could fund Social Security in perpetuity, all while reducing environmental costs and the need to pay for today's retirees. Announcing these changes a few years ahead of time could ease this transition, as could placing some carbon tax revenue into a sovereign wealth fund to accumulate for a few decades. Some beneficial features of such a fund are that government would buy diversified stocks from US firms that would actually lower the cost of capital, offset the higher cost of energy, and provide a benefit to corporate America, which then might pass through to labor.

Agreeing on a good tax rate for this policy is the last piece of the puzzle—set it too high and we slow the economy too much, while setting it too low renders it less effective than it could be. This is something we probably could not know ahead of time. Putting something in place for 20 or 30 years at a time without periodic policy review doesn't make much sense, and the use of a carbon tax would probably benefit from a yearly scientific and economic committee meeting that would decide where the current rate should be. The federal government appears to be able to do this, but we may benefit from the creation of an independent agency that can sensibly assess the data and decide what to do at any point in time.

Sometimes policy solutions seem simpler to an academic than to policymakers or voters, but my hope is that lessons from the financial sector can help bridge the gap when dealing with risk and volatility. These lessons caution that policymakers should ensure that society only takes the risks it intends, including the possible long-run risks that follow short-run outcomes. Policymakers should consider reducing exposure to long-term risks by hedging and recognize that those policies aimed at reducing long-run risks can have benefits in today's markets. Finally, implementing some sort of carbon tax with revenue funneled into Social Security is not only financially beneficial but also will help us preserve many of today's environmental assets for the future. ●

This article is an excerpt of Robert Engle's remarks, "A Financial Approach to Environmental Risk," given on March 18, 2014, as part of RFF's Nobel Laureate Lecture Series. Video footage of the event is available at www.rff.org/Engle.

Developing Policies to COMBAT INVASIVE SPECIES

Global trade—and now global warming—are making the problem of invasive species ever more challenging. From surveillance to cooperative management, ***Rebecca Epanchin-Niell*** *explores options to control these damaging invaders.*

In 1909, Tokyo Mayor Yukio Ozaki presented the US government with 2,000 young cherry trees to be planted around Washington, DC's tidal basin. The gift was part of a beautification effort for the National Mall.

There was one problem. When the trees arrived in Washington in early 1910, inspectors discovered they were infested with damaging roundworms and insects. The trees would have to be destroyed.

US Secretary of State Philander Knox informed Japanese Ambassador Yasuya Uchida of the bad news:

> *The United States has suffered immense damage to its trees and its agriculture generally by various injurious insects not indigenous but introduced from foreign countries, and . . . the introduction of any new kind might result in the future in the enormous detriment to fruit growers and agriculturists of the country. From this point of view, the Department of Agriculture seems to have no choice but the painful duty of ordering the destruction of the trees.*

Skillful diplomacy smoothed over any potential hurt feelings, and a new shipment of pest-free cherry trees arrived in 1912, the same year that Congress passed the landmark Plant Quarantine Act, among the first federal legislation dealing with importation of exotic species.

More than 100 years later, exotic pests remain very costly to the American economy, imposing billions of dollars in damages on crops and ecosystems. Invasive species are now a staple of news reports:

» The Burmese python, likely introduced as a pet and now taking up residence in the Everglades, dines on everything from small mammals to endangered birds and even alligators.

» The Asian tiger mosquito—thought to have arrived in the Port of Houston in 1985 in a shipment of used tires—is now a backyard menace in 26 contiguous states and Hawaii.

» The zebra mussel, most likely brought over from Russian freshwater lakes in ballast water, is now driving native mussel species to near extinction and clogging water intake pipes at electric utilities from the Great Lakes to the Mississippi basin.

» The emerald ash borer, probably introduced to the United States in the 1990s in wood packaging material, is responsible for the loss of more than 100 million ash trees since its first detection in 2002, with devastating economic and ecological impacts.

How Invasives Arrive

Invasive species are yet another manifestation of human impacts on the global environment, as human activity is far and away the main driver of species spreading to new areas. Many invasive species have even been introduced intentionally by individuals unaware of the potential negative consequences. To take a notorious example, the European starling arrived in 1890 as part of Eugene Schieffelin's effort to bring every bird mentioned in Shakespeare's plays to America. Many other invasive plants and animals were initially introduced as part of the horticultural or pet trade and subsequently became established in the wild.

Another important way that new invasive species arrive is by hitchhiking on other shipments, as in the case of the pests that accompanied the first gift of cherry trees from Japan. The increase in global trade and travel has exacerbated this phenomenon, with pests arriving on agricultural products, in packing material, in ballast water, and in passenger baggage.

Trade in live plants is a particularly important pathway, as it not only directly introduces plant species that have the potential to become invasive, but more importantly, it also is the most frequent medium for intro-

A captured 13-foot-long Burmese python is displayed as part of The Florida Fish and Wildlife Conservation Commission's Python Challenge 2013, a month-long program of harvesting the invasive species from public lands.

duction of non-native pests of agricultural and natural resources worldwide. Of invasive forest insects and pathogens taking root in the United States in the last 150 years or so, an estimated 70 percent are thought to have arrived on imported live plants.

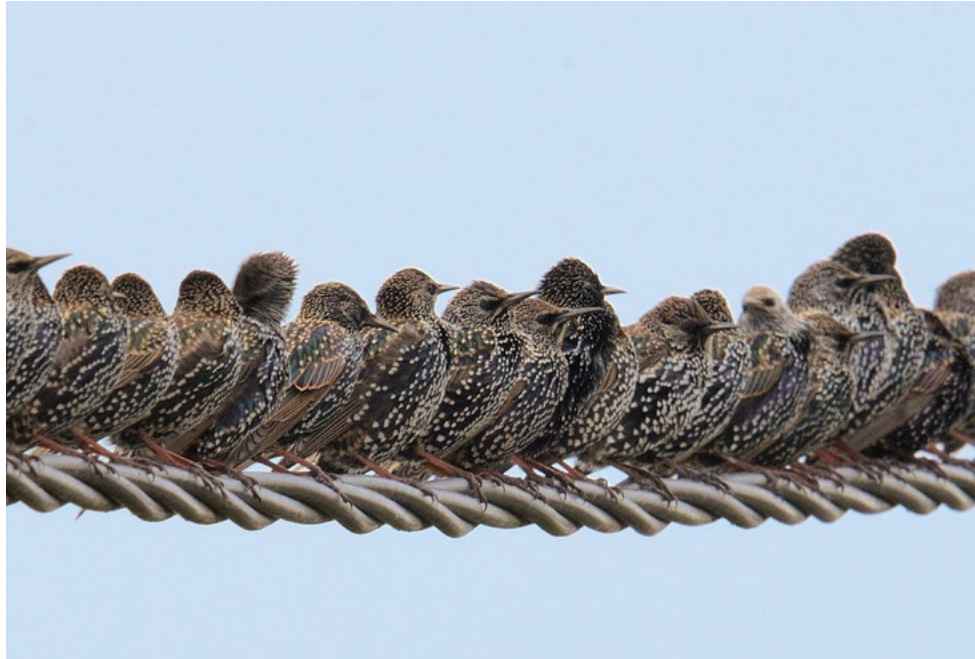
But not all alien species qualify as invasive. At a minimum, the species must be able to take hold and flourish in its new surroundings. Most introduced species are not able to do so, but a small percentage can, benefiting from the lack of natural controls like predators, competition, and climate fluctuations that would otherwise keep their populations in check. From a policy perspective, the species must also be harmful to be counted as invasive. The US government's official definition is an alien species "whose introduction causes or is likely to cause economic or environmental harm or harm to human health."

And although not all introduced species are harmful—in fact, of the food crops grown in the United States today, only a handful are actually native—enough are damaging to create serious risks for many parts of the economy. For example, the emerald ash borer alone is estimated to cause $850 million in local government control expenditures annually, as communities treat or remove urban ash trees devastated by this pest.

Developing a Toolkit for Response

The challenge facing policymakers is how best to respond to the problem. The sheer size of global trade and population flows make it impossible to thoroughly inspect each border crossing for the presence of invasives, and their tenacity once established make complete eradication impossible in many cases.

Rather than a single strategy, a portfolio of approaches is required. The first is to keep invasives from arriving in the first place. A number of measures are available



Introduced to the United States as part of a plan to populate the country with all the birds mentioned in Shakespeare's works, European starlings now compete with native species and destroy crops.

to reduce trade-associated pest introductions, including the creation of "blacklists" of banned goods, pre-treatment protocols for goods and materials (such as packing crates) known to harbor damaging pests, and inspections.

But limited resources are available for inspections compared to the volume of shipments. For example, more than 2.5 billion plants are imported to the United States each year. Inspection of these imports typically has been performed by approximately 65 full-time equivalent employees, resulting in an average flow of more than 18,000 plants per inspector per hour. Guidelines have typically recommended inspecting about 2 percent of this imported plant material. Given these limited samples and the small size and cryptic nature of many plant pests, invading pests cannot be excluded via inspection alone.

The USDA Animal and Plant Health Inspection Service, the entity responsible for the regulation of plant imports, has determined the need for the continued development of risk-based strategies to better target inspections. My colleagues and I are currently working on a project to offer guidelines for improved inspection targeting—for example, determining which types of plants and from what origins should receive more inspection—and designing inspection schemes that will increase incentives to exporting countries to reduce pest levels. One of the unique features of this work is that we also are incorporating the incentives and strategic behavior of exporters into our analysis. For example, risk-based inspection schemes, which inspect "dirtier" pathways more intensively, can encourage exporters to reduce pest levels in order to avoid costs associated with inspections.

But even the best-designed inspection strategy will not be 100 percent effective. This is where the importance of surveillance for new outbreaks comes in. How can we

best detect a newly establishing population early, when it is less costly to contain or eradicate? Again, this is a case where the resources available to governments do not allow for total coverage, and cost-effective targeting must take place. As such, with colleagues, I have been developing models to determine how surveillance efforts should be targeted across the landscape in order to detect new invasive species populations most cost-effectively, based on how invasion risk, damages, and costs are distributed across the landscape.

For example, to address New Zealand forest owners' concerns about potential future introductions of wood-boring pests that could devastate the timber industry, we developed a model to evaluate the costs and benefits of implementing a trap-based surveillance system for early detection. We found that implementing the program would provide positive net benefits of around $300 million over the next 30 years by allowing for a higher probability of wood-borer eradication and exclusion. We also showed how trapping efforts should be allocated across port regions, with more traps in areas with higher rates of pest introduction and greater proximity to at-risk forest resources.

For those species that slip though both inspections and surveillance, the question becomes one of management: Where should we be controlling them and how? This requires a thorough understanding of the economic losses being incurred, the costs of the interventions, how invasions spread across the landscape, and any risk–risk trade-offs, such as the side effects of additional pesticide and herbicide use. For example, some of my work has identified spatial strategies for controlling invasive species—by targeting control to protect at-risk resources and strategically using landscape features, such as mountains and rivers, as natural barriers to reduce the costs of management.

Further complicating the management of established invasive species is the challenge that they can spread across jurisdictional boundaries—between neighboring ranches, or even from the land of one management agency to another's. If a land manager in one location fails to control an invasive species, it can then spread to new areas or reinvade locations where it has previously been controlled. So coordinating approaches to control invasive species across properties can be critical for effective management. We have been conducting research to identify when coordination is most essential and how it can be encouraged to reduce the economic impacts of invasions.

A Growing Challenge

The need for effective invasives policy will only continue to grow as trade continues to expand and open up new pathways for the arrival of pests. A wild card is climate change: the hallmark characteristic of invasives is their adaptability, and it is possible they will be best positioned to take advantage of longer growing seasons, expanded ranges, and other phenomena associated with a warming world. ●

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Preparing for the Midterm **CAFE** Review

New fuel economy rules are designed to slash fuel use, carbon dioxide emissions, and compliance costs. But ***Alan J. Krupnick****,* ***Joshua Linn****, and* ***Virginia McConnell*** *argue that questions remain about their effectiveness.*

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Our country is entering a critical time for the future of transportation and its associated greenhouse gas (GHG) emissions. Corporate average fuel economy (CAFE) and GHG standards for both light-duty vehicles and heavy-duty trucks are slated to tighten, reducing not only oil use but also GHG emissions. Although the severity of future heavy-duty truck standards is still uncertain, the new fuel economy standards for light-duty vehicles may cut the GHG emissions rate from the new car fleet to nearly half its current level by 2025.

The light-duty vehicle standards were established in 2012 jointly by the US Environmental Protection Agency (EPA) and the Department of Transportation's National Highway Traffic Safety Administration (NHTSA). The standards require annual reductions in GHGs and fuel consumption, such that new vehicles sold in 2016 must reach an average tested fuel economy of 35 miles per gallon (mpg) with associated GHG reductions, ramping up to 55 mpg by model year 2025. Part of the negotiation over the final rule was that a mandated midterm review will reevaluate the basis for the standards that apply to the last years covered by the rule, model years 2022–2025, drawing on evidence and studies since the original evaluation was performed. The review must occur by November 15, 2017, and final decisions are due from the agencies by April 1, 2018.

The next several years will be an important time for research that can enhance this evaluation and inform future policies to reduce GHG emissions and oil use from the light-duty fleet. Major questions remain about consumer and manufacturer responses to the regulations and the best methods for estimating the costs and benefits. RFF's transportation team has begun to address some of these issues, including the implications of the fuel-efficiency gap, the shift to a footprint-based standard, and the effects of the credit provisions that are designed to provide flexibility to the automakers.

What Is Causing the Fuel-Efficiency Gap?

The goals of the new CAFE standards are to reduce greenhouse gas emissions, improve energy security, and reduce consumers' fuel costs. When EPA and NHTSA estimated the costs and benefits of meeting the standards in the recent rulemaking, they concluded that the overall benefits would be roughly three times the costs. Indeed, even the benefits to consumers in the form of reduced fuel costs were estimated to be higher than the costs of adding the needed technologies to new vehicles.

With such large fuel savings, we would expect consumers to demand fuel-saving technologies and manufacturers to adopt them. But we don't see this happening in the marketplace. This outcome—that consumers do not appear to want to pay up front for the full value of energy savings over the life of more efficient technologies—is often referred to as the fuel-efficiency gap.

There is a large literature that attempts to examine why there might be such an efficiency gap. One explanation is that there is no gap, but rather there are hidden costs of the new technologies. For example, consumers may prefer other attributes that enhance performance or operation of the vehicle compared to the additional fuel economy. Or, there may be additional adoption costs (real or perceived) from raising fuel economy that are not included in the cost estimates.

Consumers may not be aware of how much fuel they will save over time with a more fuel-efficient vehicle, either because they have difficulty calculating the savings correctly or because it is not a salient feature compared to other attributes. Or there may be a great deal of individual variation in actual fuel economy for any given vehicle relative to its labeled fuel economy because of differences in driving conditions, driving style, or type of fuel used.

In addition, manufacturers appear slow to bring fuel-efficient vehicles to the market for other reasons. Evidence is growing that consumer demand for fuel economy is quite heterogeneous. Consequently, manufacturers don't choose fuel economy based on average consumer demand. Instead, they may design some vehicles for consumers with a high willingness to pay for fuel savings and other vehicles for consumers with a low willingness to pay. Another possibility is that manufacturers decide to adopt technology based on what their competitors are doing. Either case could cause technology adoption to be slower than if manufacturers simply compared technology costs with the value of the fuel savings.

It is interesting that some research has

found little evidence of an efficiency gap, suggesting that consumers are willing to pay just slightly less than $1 for $1 worth of expected fuel savings. One potential problem, however, is that these studies tend to use fuel price variation to estimate consumer trade-offs between vehicle costs and fuel savings—perhaps an inaccurate measure.

The presence and magnitude of the fuel-efficiency gap should be addressed because the stakes are high. Depending on the outcome, the regulatory agencies may need to adjust their cost–benefit approach, which could change the calculations and shed light on whether the slated tightening is justified—or if there should be even tighter standards. And taking into account consumer heterogeneity or competition among manufacturers would suggest that other policies—raising the gas guzzler tax or setting a minimum standard, for example—could yield the same benefits at lower costs than a fuel economy standard. More study is needed here.

Will a Footprint-Based Standard Reduce Fatalities?

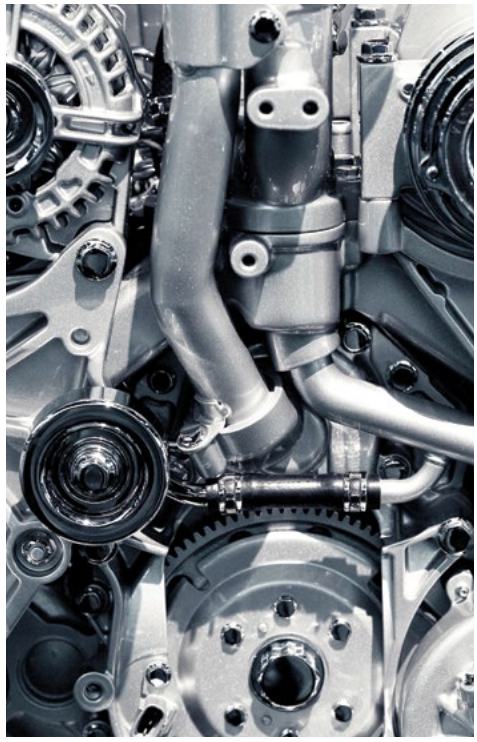
Until the changes to the CAFE rules in 2012, all passenger cars were held to the same fuel economy standard—27.5 mpg from 1990 to 2011—and all light-duty trucks were held to a weaker standard of between 20 and 23 mpg. But federal legislation in the late 2000s required the regulatory agencies to base the new standards on a vehicle attribute or attributes related to fuel economy. In response, EPA and NHTSA based the new standards on a vehicle's footprint, defined as the area between the four wheels, and they also maintained the car–truck distinction. Vehicles with a smaller footprint must meet a tighter standard than those with a larger footprint, and light-duty trucks still have a less stringent overall footprint standard than cars.

Before making this decision, the agencies considered several attributes on which to base the standards. European, Japanese, and Chinese standards depend on vehicle weight, with heavier vehicles allowed to have more lenient standards. The agencies argued that a footprint standard, by comparison, would fall relatively evenly on all manufacturers and force more technology for improved fuel economy across all vehicle sizes, with less incentive to downsize to meet the standard. This was especially appealing to NHTSA, which was particularly concerned that, with so many large vehicles on the roads, downsizing new vehicles would result in more fatalities.

But will the footprint standard work as expected? The effect of CAFE standards on traffic fatalities is highly controversial. Bigger and heavier vehicles are safer in single-vehicle accidents and are safer for their own occupants in multi-vehicle crashes. But drivers and passengers face greater risk in an accident with a larger or heavier vehicle than with a smaller or lighter one. Furthermore, analysis by NHTSA researcher Tom Wenzel recently concluded that reducing weight while holding the footprint constant does not increase fatality risks; this is one of the primary reasons the agency favors the footprint-based standard.

Adding to the complications, some research suggests that optimal vehicle

The new rules allow manufacturers to trade with each other for the first time, but only a handful of trades have taken place to date.



weight may be significantly smaller than the current average weight of vehicles on the road. Consumers believe that they are safer in heavier and larger vehicles, but they don't account for the fact that choosing larger and heavier vehicles increases fatality risks for people in other vehicles. Because of this safety externality, consumers choose vehicles that are larger and heavier than is socially optimal.

Will the new CAFE standards reduce or exacerbate this problem? The truth is, we don't yet know. Because size and weight disparity matters, the effect of CAFE standards on fatalities depends on how the standards affect the entire distributions of size and weight. It also matters whether CAFE causes riskier drivers to buy different vehicles. Predicting these effects is essential to predicting how the standards will affect accident fatalities.

The agencies assume that there will be no change in vehicle size or sales mix, but rather that the effect of the standards will be to improve fuel economy uniformly across the fleet. It seems likely, however, that the sales mix and vehicle sizes will change in response to differences in the costs of improving fuel economy across different vehicle sizes and types and to differences in consumer responses as new vehicles are introduced over time. The important questions are, what will be the direction and magnitudes of these effects, and will they change the expected outcomes of the new rules on safety and GHG emissions?

Several studies have taken a first look at the effects of footprint standards on vehicle size and fleet sales mix. Researchers Kate Whitefoot and Steven Skerlos, using data from earlier regulatory analyses and a combined economic–engineering model, conclude that manufacturers are likely to increase vehicle size, particularly for larger vehicles.

How Will Trading Provisions Affect the Rules?

Each manufacturer has target fuel economy and GHG emissions of its fleet in each year under the new rules. Provisions in the rules allow companies to earn credits for reducing the fuel consumption and GHG emissions on individual vehicles below their targets set by the standards. The new rules allow manufacturers to bank, borrow against, and trade those credits. Credit trading provides manufacturers with flexibility and can lower the costs of meeting these strict new standards, especially when the costs of complying vary across vehicle models.

For some vehicle sizes and models, it will be less costly to add fuel-saving technologies than for others. In addition, consumers of some models may be willing to pay more for that technology than consumers of other models. Crediting allows manufactur-

ers to sell some vehicles that exceed their standard and others that fall short of the standard—but still meet the overall GHG and fuel consumption targets in the most cost-effective way.

Is there evidence that manufacturers will take advantage of this crediting flexibility? Indeed, some recent developments suggest that they will. In model-year 2012, most manufacturers did not meet the standards in their truck fleets and earned credits or at least had fewer deficits in their car fleets. In addition, some manufacturers seem to be taking opportunities to bank credits for the future. Manufacturers were allowed to overcomply and accumulate credits before the new standards began, and a number of them did so. These manufacturers seem to be taking advantage of the flexibility to average credits across the car and light-duty truck fleets and over time.

The new rules allow manufacturers to trade with each other for the first time, but only a handful of trades have taken place to date. A possible barrier to a competitive and robust trading market is the fact that three manufacturers accounted for close to 80 percent of the overcompliance credits outstanding as of 2012. Uncertainty about future costs of complying with the rules is another reason manufacturers may be reluctant to participate.

However, the fact that EPA's compliance rules are different from those of NHTSA may encourage future cross-manufacturer trades. The current CAFE rules under NHTSA allow manufacturers to pay a penalty if they do not comply, and a number of manufacturers have often done exactly that. Under the new rules, penalties under the Clean Air Act are so high that they are effectively not an option—the companies must comply. This increases the value of trading credits across companies. Whether and how this market develops over the next few years is likely to be key for the success of the CAFE rules.

For the research community, the midterm CAFE evaluation is an important invitation to perform research that can aid the agencies in their deliberations.

Informing the Midterm Review

For the research community, the midterm CAFE evaluation is an important invitation to perform research that can aid the agencies in their deliberations. Although the academic literature on vehicle markets has grown in recent years, major questions remain—a point that the agencies readily acknowledge. Because the midterm review will not be completed for another three years, there is sufficient time to undertake significant new research to address these questions. The time to start is now. ●

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UTILITIES *and the* US ENERGY REVOLUTION: *Confronting a Shifting Landscape*

In an excerpt from his remarks at an RFF Policy Leadership Forum, ***Chris Crane****, president and CEO of Exelon, shares his thoughts on how the electricity industry is responding to major changes in how energy is produced, delivered, and consumed.*

On the Natural Gas Boom

The advent of shale gas, as we all know, has been a game changer. Having plentiful, cheap gas is great for the economy and for industry.

That said, it's caused all of us in the industry to reexamine our investments. Shale gas and renewables have decreased the margins of conventional fuel profits. They have made many coal plants and some nuclear plants less economically viable—to the extent that if we were to build a new generation facility right now, we would build natural gas. The problem is, as an industry, we're all going to the same fuel source again. So fuel diversity is an important consideration for maintaining competitiveness—one that the independent grid operators should keep in mind as they design their capacity markets.

Take, for example, this past winter, when we saw a noticeable shift from oil to natural gas for heating homes. We had to move more generation to natural gas to meet demand during a very cold period. Home heating became the top priority. If you disrupt gas to a large population, just the time to relight the pilot lights could have a significant effect. This winter our transmission was constrained, and there

were natural gas plants—including some of our own—that failed to meet demand. As a result, there was a dependency on some of the old coal units that are about to retire to be able to meet the load during that period.

By contrast, if we load the core of a nuclear plant and fuel it to run 18–24 months, it does not matter what the weather is like outside—that plant runs, so it's highly reliable. It can support the needs of the grid in stress periods. I think the market design must compensate assets for their capability around that. If a natural gas plant has a dual-fuel mix with oil storage to meet those peak capacity needs, it should have a compensation mechanism.

On Renewables and Distributed Energy

Exelon has a small distributed generation business. It is a customer-facing product that we offer to our larger industrial customers who receive gas and electricity now, but if they want solar panels, we will install them. We also are doing a deep evaluation of fuel cells, as we look at potentially expanding our business line. For example, I have spent time at the Toshiba research facility in Yokohama, Japan, learning more about how its engineers are perfecting the manufacturing and efficiency of fuel cells for the residential level. Researchers at Bloom Energy in San Jose, California, are doing fantastic work on their industrial-scale solid oxide fuel cells, which are much larger. So technology is advancing, but we need to design a system that is reliable and fair to all consumers.

Exelon is piloting a microgrid with the Illinois Institute of Technology in Chicago, and the focus of the project is on reliability. If the grid goes down, the hospitals, the University of Chicago, a very important police command center, and other critical infrastructure would isolate from the grid, and the distributed generation would pick up and run. That's a neat concept. It's all about reliability and security. There is a defense mechanism in there, but at the end of the day, that customer base still needs to be attached to a larger grid to provide economic-scaled generation.

Steam vents from a cooling tower at Exelon's Limerick Generating Station, one of its 10 nuclear power plants.

On Subsidies and Customer Choice

People should have choice, but it should be understood that we cannot continue to subsidize everything. When customers want to have a microgrid, that should be facilitated for them within the regulatory framework and the utility's suite of products that they offer. Consumers can then decide from there.

Likewise, if you put a solar panel on your roof, that is your choice. If you have excess power and want to sell that power back to the grid, that's fantastic for the grid, but what has to happen to enable that? The design of the local distribution system has to handle the voltage fluctuations. Every customer has a specific service capacity. If a family has a 200-amp service entrance on their house, that utility distribution system needs to be designed to provide them 200 amps at any instantaneous moment they want. Just because they install a solar panel does not mean they are disconnecting from the grid. There's a dependency, but there should be an enabling on the grid to allow for solar, and the consumer should be compensated at the wholesale price of energy.

On the Future of Nuclear

Looking forward, we predict long-run natural gas will cycle between $4 and $6 per million British thermal units. As prices come down, development will slow. As prices

come back up, they will spur more development. Significant seasonal differences could break through that swing, but they will be momentary.

The majority of our nuclear fleet can compete in that range, but there are exceptions. We have a few units that are small in size but require the same security force as our larger units, carrying a much greater overhead. We have to be realistic. We're not saying we should be subsidized; nobody should be subsidized in the competitive market, so consequently a few units might not make it. We are retiring a preannounced facility, Oyster Creek, in New Jersey in 2019. It's a struggling unit today, and we continue to evaluate its performance.

The other units that are challenged are larger, more reliable, dual-unit sites that sit in transmission-constrained zones, with an oversupply on off-peak hours of wind, which is causing price suppression. So it's very tough to compete in those environments.

What both types of units have in common is they have to compete in a lower-margin environment with a higher baseline price. We are experiencing inflation in operating costs across the fleet. Fukushima is not immaterial. For instance, new seismic regimes are just coming out that require us to go back and validate our seismic spectra for the plants and the design. The cost of labor escalates at about 3 percent a year, and the supply chain has been expensive.

Regulation issues have probably had the biggest impact since 2000. After 9/11, there was a significant change in our security costs. We all employ paramilitary forces at our sites who are true professionals, and fulfilling critical technology requirements is very expensive.

On the Prospects for Modular Reactors

Looking a decade or more out, I predict the focus will shift to small, efficient modular reactor designs. These reactors can be completely manufactured in a factory and then delivered and installed. Given support for a different regulatory regime that takes into consideration the risk associated with an accident, these modular reactors will cut down the capital cycle for the investment.

If you're building a dual-unit nuclear plant today, it costs about $16 billion, spent over eight years. Modular reactors, coupled with a smaller safety force, could cut that capital cycle down to two years, and then you would start to see a return on investment.

So we are putting a lot of work in following the modular reactor design process. The Nuclear Energy Institute has taken the lead in working with government to figure out what the regulatory framework needs to be to support them. Maybe not within my career but, hopefully, in the future, we'll start to see the modular reactors play a significant role.

One other critical consideration is the uncertain future of water availability. Heat maps show us that by 2050, droughts will plague even Florida. So starting with the western states, generation technology must start to focus in on air-cooled condensers, with less dependency on water. The modu-

In response to shifts in the US energy landscape, a polarizing debate is taking place in the industry. Wind is arguing against nuclear, and solar's off on its own, arguing against the world.

Chris Crane joined RFF President Phil Sharp at the May 13 Policy Leadership Forum for a conversation about the massive shifts affecting the energy industry.

lar reactors lend themselves to the utilization of that technology much better than a large-scale generation facility.

On Taking an All-of-the-Above Approach

In response to shifts in the US energy landscape, a polarizing debate is taking place in the industry. All of us with commercial interests are stating our opinion. Nuclear is arguing against wind. Wind is arguing against nuclear, and solar's off on its own, arguing against the world. It would be much more constructive if we could come to the table with policymakers and demonstrate the benefits of an all-of-the-above clean stack, along with the economic advantages each one can provide.

How do you have complementary design systems? Solar is a complementary design to a base-load nuclear plant. As the sun comes up, the load starts to pick up, and solar is able to pick up that load. As the solar generation comes off, you get back down to base load. For wind generation, you figure out how to feather in enough wind and have the right amount of investment in gas as a backup.

Renewables need to be backed up with a carbon-based source. There's no getting around it right now. The technology is not advanced enough to make an economic storage system. That may change in coming years, in which case carbon-based electricity will be a transition source. But the

demise of central-station power and utility distribution systems is overstated at this point. Getting to the table and designing a future together is a much more productive way to go.

On New Carbon Regulations

I believe that if there is a push to change the emissions profile of the US generating sector, it either should be through legislation or regulation. The Obama administration now seems to be going the regulation route, with the Clean Air Act Section 111(d) rules for reducing emissions at existing power plants, which direct the states to have their own profiles on carbon reduction. That could go a long way toward individual state designs but also provide an opportunity for more states to participate together.

Many states are net importers of generation and will have a much more difficult time meeting the goals of 111(d) without combining into a regional greenhouse gas scenario. Other states, such as Illinois, would be greatly challenged to meet a greenhouse standard if nuclear plants start to retire. Getting all the players together to assess the requirements of each asset that needs to stay in the stack to meet the goals would be greatly beneficial. ●

Video footage of the May 13, 2014, RFF Policy Leadership Forum, "Energy Revolution: Utilities Confront the Shifting Energy Landscape," is available at www.rff.org/energyrevolution.

What Americans Think about CLIMATE CHANGE

Polling Americans about climate change reveals a largely united desire for government action—and other surprises. ***Jon A. Krosnick****,* ***Nuri Kim****, and* ***Bo MacInnis*** *report.*

On many issues, public opinion is so evenly divided that it does not provide a clear signal to government—but that's not true on the issue of climate change. During the past 17 years, our research team has been tracking Americans' opinions. Most recently, we teamed up with RFF to conduct in-depth surveys of Americans on climate change and energy policies. Polls were administered in December 2013 (in partnership with *USA Today*) and again in June 2014 after the Obama administration's proposal on June 3 to regulate greenhouse gas emissions from existing power plants through the Clean Air Act.

Our surveys suggest that Americans have been overwhelmingly "green" on climate change issues for many years, despite a barrage of natural disasters, media events, and campaign speeches that one might have imagined would impact such opinions.

As the Obama administration continues its efforts to restrict greenhouse gas emissions, these surveys allow us to compare the administration's actions with the American public's beliefs about global warming and preferences regarding government efforts to address it.

The Fundamentals

Over the years in which we've tracked public opinion, we have seen very little change in various "fundamental" beliefs about climate change:

Has the Earth been warming?

» According to our latest survey results, 73 percent of Americans believed that the world's temperature has probably been increasing over the past 100 years, down a little from the 77 percent we observed in 1997 (Figure 1).

Has warming been caused by human activity?

» Seventy-eight percent of Americans said that if warming has been happening, it's been due to human activity—the same percentage we found in 1997 (Figure 1).

Will warming continue?

» And 76 percent said that the world's temperature will probably go up during the next 100 years if nothing is done to prevent it.

Is warming a threat?

» In 2013, 60 percent of Americans said that the increase in the world's temperature during the past 100 years was a bad thing.

» Sixty-six percent of Americans said that if the world's average temperature goes up 5 degrees Fahrenheit during the next 75 years, that would be bad as well, about the same as the 61 percent of Americans who said so in 1997.

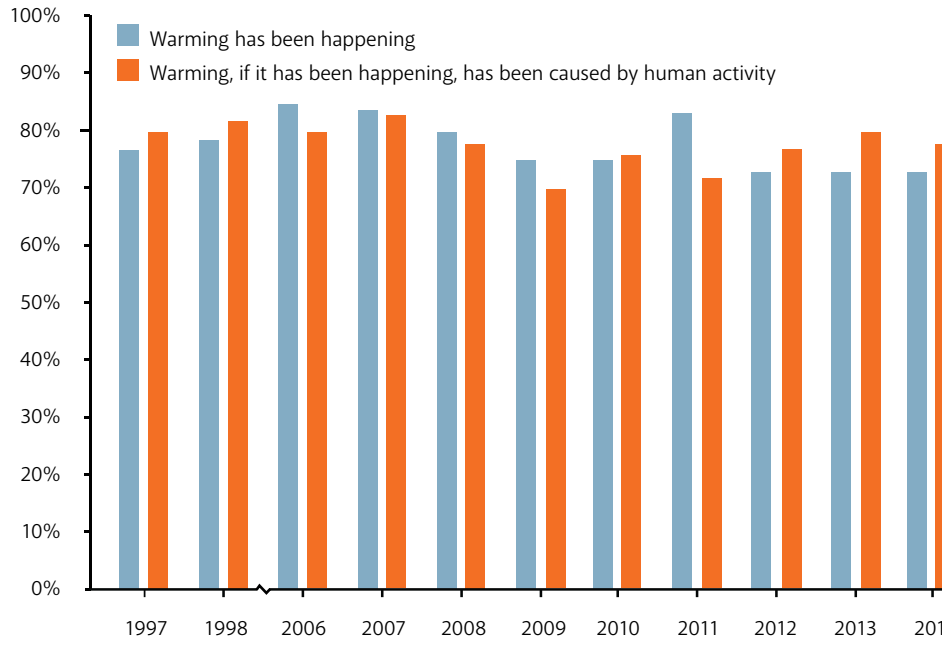
» Only 32 percent of Americans said in 2013 that global warming will hurt them personally either a great deal or a lot if nothing is done to reduce it in the future, but 67 percent believed that global warming will hurt future generations a great deal or a lot.

» Eighty-one percent of Americans said that global warming will be a very serious or somewhat serious problem for the United States.

» An equally large majority, 83 percent, said global warming will be a very serious or somewhat serious problem for the world if nothing is done to reduce it.

These majorities have been quite consistent over the years since 1997. So we see that most Americans are "green" on this issue, and they have been for some time.

Figure 1. Proportions of Americans Who Believe That Global Warming Has Been Happening and That It Has Been Caused by Human Activity



The Weather

According to our 2013 survey, most Americans believed they had seen changes in climate in recent years that were caused by global warming. Sixty-two percent said that global warming has caused more storms, and 60 percent said it has caused more droughts. Fifty-seven percent said that it caused the damage of Hurricane Sandy to be worse.

Fifty-seven percent of Americans said that global warming caused the damage of Hurricane Sandy to be worse.

Government Action

Even if large numbers of Americans have believed that warming is happening, is human-caused, and poses a threat, such beliefs may not necessarily translate into support for government action to deal with the issue. However, our surveys have documented substantial support for government action.

A remarkable 81 percent said that government should limit greenhouse gas emissions by American businesses. And various specific policy approaches have been evaluated positively by most Americans. Government efforts to require or encourage (through tax breaks) construction of more energy-efficient buildings, cars that use less fuel, and appliances that use less electricity were viewed favorably in 2013 by 74 percent, 72 percent, and 71 percent of Americans, respectively. Government requiring or encouraging the building of all-electric cars was slightly less popular, with 59 percent of people favoring this idea in 2013. We described a national cap-and-trade system in various different ways in 2013 to different respondents, and the proportion of people favoring it varied from 48 percent to 65 percent. A large majority of Americans—79 percent in 2013 and 77 percent in 2014—said that government should require or encourage power plants

Figure 2. Proportions of Americans Who Want the Federal Government to Take Steps to Reduce Greenhouse Gas Emissions by Power Plants

Flags hang on a house that was destroyed by Hurricane Sandy in the Belle Harbor neighborhood of New York.

to reduce their greenhouse gas emissions (Figure 2).

Subsidizing green energy production was also very popular. A majority of Americans, 66 percent, said federal tax breaks for oil companies should be stopped; 42 percent said the same about the tax breaks for natural gas companies. In contrast, a large majority (73 percent) said that tax breaks for companies that make electricity from sunlight, wind, and water should be continued. Similarly, 68 percent of Americans said that government should continue to pay part of the cost for people to put solar panels on their homes, and 71 percent thought that government should give money to companies to help them develop new ways of making electricity that emit fewer greenhouse gases than burning coal, natural gas, and oil.

These policy preferences were consistent with the public's general attitudes toward various methods of generating electricity. A whopping 91 percent of the public said that generating electricity from sunlight was a good idea, and 84 percent and 83 percent said so about wind and water, respectively. Only 48 percent said production of electricity from natural gas was a good idea, 33 percent said so about nuclear power, and a mere 21 percent said so about coal. However, Americans were divided about whether non-fossil energy sources can provide all of the electricity that the United States needs: 52 percent said all of it or most of it can be made from sunlight, wind, natural flowing water, and nuclear power.

Other policy approaches were much less popular. For example, just less than half of Americans (49 percent) favored imposing carbon taxes on power companies, and only 37 percent of Americans favored government giving companies tax breaks to build nuclear power plants.

Some observers have asserted that government efforts to reduce future global warming would reduce American economic competitiveness and vitality. Most Americans did not endorse this view. Only 27 percent in 2014 said that efforts to reduce global warming will hurt the US economy, the same number observed in 2009.

Americans also favor taking action on this issue unilaterally. Specifically, 75 percent of 2013 survey respondents said that the United States should take action on global warming, even if other major emitting countries do less. And 83 percent preferred

taking action soon to prepare for the possible effects of global warming before they happen, rather than waiting to see if global warming has any effects and dealing with them then.

Most Americans wanted the federal government to increase its effort on this issue. In 2013, only 12 percent wanted the federal government to do less than it was about global warming, whereas 66 percent wanted the federal government to do more. A majority of Americans (52 percent) said that they wanted the federal government to do a great deal or a lot about global warming, and only 21 percent said that the federal government should do a little or nothing. Yet most Americans believed that the federal government had been doing much less than they'd like. Only 10 percent said that the federal government was doing a great deal or a lot about global warming, and a majority, 57 percent, said the federal government was doing a little or nothing. These results signal a prevalent desire for increased effort.

In 2013, only 12 percent wanted the federal government to do less than it was about global warming, whereas 66 percent wanted the federal government to do more.

The 2014 Elections

In recent months, President Obama has reiterated his long-standing commitment to reduce greenhouse gas emissions in the United States in various forums, and the US Environmental Protection Agency moved forward with regulations to limit the emissions of power plants. Are these dangerous moves during an election year? Might such "green" efforts hurt the electoral chances of the Democratic Party?

According to our most recent survey and other research we have done, the answer is no. In fact, taking steps along these lines is likely to please a much larger group of voters than would be displeased by them. In particular, such moves impact the political thinking and action of the people who attach tremendous personal importance to the issue—the citizens whom political scientists call the "global warming issue public." In our 2013 survey, almost one in every five Americans fell into this group—the largest we have ever seen and larger than the groups passionate about many other major national issues. The overwhelming majority of these passionate individuals are on the green side of the global warming issue, who are likely to be inspired to vote more often for Democrats as a result.

Our work indicates that if Republican candidates endorse the same "green" policies, they will neutralize the advantage likely to be reaped by Democrats doing the same. When competing candidates take identical positions on an issue, the issue is no longer a meaningful basis for differentiating between the candidates and therefore has no impact on voters' choices.

Taken together, these results paint a portrait of a largely "green" public on this issue. No doubt, it will be fascinating to watch public opinion and government policymaking during the coming months and years to see whether they come more into line. ●

A Look at What's Happening

Inside RFF

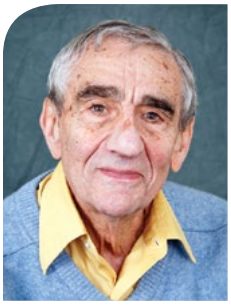
RFF University Fellow and Princeton University Professor **Simon Levin** was awarded the 2014 Tyler Prize for Environmental Achievement for his research revealing multifaceted relationships between species and ecosystems and his foundational role in shaping environmental policy and advancing the study of complex ecosystems.

Molly Macauley, RFF vice president for research and senior fellow, participated in the National Research Council's Space Studies Board for the Standing Committee on Earth Science and Applications from Space at the National Academies. Macauley also served as a Distinguished International Visitor at the invitation of the government of Quebec and met with industry representatives, scholars, and government officials.

James Boyd, RFF senior fellow and director of the RFF Center for the Management of Ecological Wealth, served as a panel member on the Mississippi River Diversions Planning public hearing for the Louisiana Coastal Planning and Restoration Authority in New Orleans.

The Association of Environmental and Resource Economists has just released its new official research journal, *Journal of the Association of Environmental and Resource Economists*, published by the University of Chicago Press. Several RFF researchers, fellowship recipients, and collaborators serve on the editorial board, including Senior Fellow **Maureen Cropper**, University Fellow **John List** (University of Chicago), and University Fellow **Stephen Polasky** (University of Minnesota).

Joel Darmstadter Receives Adelman-Frankel Award



RFF Senior Fellow Joel Darmstadter has been named the 2014 recipient of the Adelman-Frankel Award by the United States Association for Energy Economics (USAEE). According to the USAEE, the award is given to recognize an individual or organization's "unique and innovative contribution to the field of energy economics." Darmstadter is the 18th awardee since its inception in 1999, joining a list of notable academics, public officials, and specialized groups. Upon receiving his award at the International Association for Energy Economics (IAEE) International Conference, Darmstadter delivered the following remarks:

"Various USAEE/IAEE publications have addressed the issue of climate change over the years—most recently, the special *Energy Journal* collection of Energy Modeling Forum 24 (EMF 24) papers on 'US Technology and Climate Policy Strategies.' Its online posting is especially timely, as we approach next year's multi-country negotiations in Paris to create, as dictated by the United Nations Framework Convention on Climate Change, a successor to the flawed and ill-fated Kyoto Protocol. While the EMF 24 work concentrates largely on potential US initiatives, the virtually concurrent, globally oriented Fifth Assessment Report of the Intergovernmental Panel on Climate Change—and particularly the energy-sector mitigation scenarios of its Working Group III—have closely explored a time path designed not to breach something like a 2° Celsius rise in global temperature in this century.

It's sufficiently challenging to figure out the fuel-switching, conservation, carbon-capture, and other approaches needed to achieve this target. And skillful application of energy economics and the insights of energy economists are clearly an important part of confronting the challenge ahead. But it also means—keeping in mind the imperative of global participation—that issues of governance, equity, enforcement, and much else have to be part of designing and implementing an effective new regime. In that context, it's worth recalling that four years before his admired 2013 book, *Climate Casino,* made the argument more pointedly, Bill Nordhaus noted in his 2009 *Energy Journal* article ('The Impact of Treaty Nonparticipation on the Costs of Slowing Global Warming,' volume 30, special issue 2) that 'for a global public good like reducing CO_2 emissions, achieving a high level of participation is a critical feature of an efficient policy.'

That said, count on the need for negotiators in Paris to consider a mechanism enabling a country's international responsibility, as signaled by Nordhaus, to match its affordability, as perceived or claimed in the light of economic reality. With a need for stepped-up momentum in dealing with global warming clearly of the essence, I'd be amazed if these considerations did not significantly engage the professional activities of many at this conference. Prolonged hesitancy in tackling this challenge is a luxury we can't indulge."

Highlights from Recent Journal Articles by RFF Researchers

Regulating Greenhouse Gases from Coal Power Plants under the Clean Air Act

Joshua Linn, Erin Mastrangelo, and Dallas Burtraw

Journal of the Association of Environmental and Resource Economists | Spring/Summer 2014 | Vol. 1 | No. 1 | 97–134

In this paper, the authors use a model of power plant operation and efficiency investments to compare the cost-effectiveness of alternative policies to reduce greenhouse gas emissions from coal plants. The results indicate that a 10 percent increase in coal prices causes a 0.1–0.4 percent improvement in efficiency. Coal prices also have a significant effect on utilization. Using the estimates to compare alternative policies reveals that performance standards are less efficient than a tax because they cause greater utilization.

Floodplain Conservation as a Flood Mitigation Strategy: Examining Costs and Benefits

Carolyn Kousky and Margaret Walls

Ecological Economics | August 2014 | Vol. 104 | 119–128

As interest in floodplain conservation as a flood damage reduction strategy grows, the authors of this paper evaluate one such investment in the form of a greenway along the Meramec River in St. Louis County, Missouri. They estimate the opportunity costs, avoided flood damages, and capitalization of proximity to protected lands into nearby home prices. The proximity benefits alone exceed the opportunity costs; the avoided flood damages further strengthen the economic case.

Managing Shoreline Retreat: A US Perspective

Carolyn Kousky

Climatic Change | May 2014 | Vol. 124 | No. 1–2 | 9–20

Kousky considers how society can proactively manage shoreline retreat in those locations where it is required or deemed preferable. A three-part strategy is proposed: (1) reduce new development in the highest-risk areas; (2) adopt policies that allow for expected and orderly removal or modification of development as inundation occurs; and (3) take advantage of disasters to implement managed retreat approaches. Specific policies are recommended, and the challenges of institutional change are discussed.

Does a Detailed Model of the Electricity Grid Matter? Estimating the Impacts of the Regional Greenhouse Gas Initiative

Daniel Shawhan et al.

Resource and Energy Economics | January 2014 | Vol. 36 | No. 1 | 191–207

Because of the complexity of power grid operation, computing limitations until now have made it impossible to solve a policy analysis that combines realistic modeling of flows with a detailed transmission system model and the prediction of generator investment. To evaluate the amount of detail necessary, the authors simulate the effects of imposing a price on carbon on power plants in nine northeastern US states. They consider three grid models of varying complexity. Most of the impact predictions produced by the two simpler models differ from those of the most complex by more than 20 percent, and some by much more.

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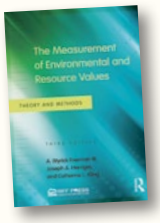

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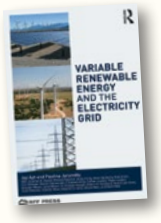

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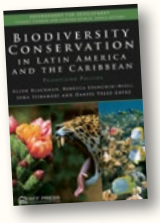

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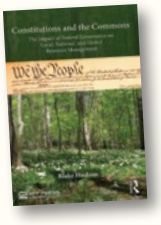

Constitutions and the Commons

The Impact of Federal Governance on Local, National, and Global Resource Management

By Blake Hudson

March 2014
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