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Cover photo: Tourists witness an eruption of the Old Faithful Geyser at Yellowstone National Park, where the surge in visitations over the past 10 years has led to entrance delays, parking shortages, and miles-long traffic jams.

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RFF's Compelling Future

I write this letter, my first as Resources for the Future's president, with a range of emotions. I am thankful for RFF's prior stewards, and I am honored and excited to lead this institution, with its remarkable heritage and a mission more vital than ever. Yet I am also saddened by the deep loss we recently suffered upon the death of RFF's Vice President for Research Molly Macauley.

RFF's former president Phil Sharp successfully connected RFF's research to important societal decisions, and I have personally appreciated his counsel. RFF also owes a deep debt of gratitude to Linda Fisher, vice chair of RFF's Board of Directors, who served as the institution's interim president this summer and provided leadership at a crucial moment.

At a time when polarization and superficial rhetoric dominate public discussion, RFF provides balanced, data-driven research and analysis to support the decisions required for a thriving environment, economy, and resource base. The landmark advances that have emerged from this institution continue to inform our public policies as well as business and individual decisions in fundamental ways. Given the critical national and global challenges we now face, if RFF didn't already exist, someone would have to create it.

RFF derives its strength from its purpose and its people. From its inception to the present day, RFF has been home to people of the highest quality and integrity, working diligently to make the world a better place. One of those people was Molly Macauley.

Molly died tragically in July. Her death is a tremendous loss for RFF, on both institutional and personal levels. The same holds true for many communities outside of RFF, especially her friends at NASA and from the broader space policy community, the

National Academy of Sciences, and Johns Hopkins University.

Molly was a pioneering economist, bringing the orientation of a resource economist to an area that needed it: space policy. She recognized that our use of space is subject to the same types of resource constraints as canonical global public goods, such as the oceans and atmosphere. The insight is classic Molly: creative, sharp, and pragmatic. Her specific contributions include research on orbital debris, space risk management, and the value to society of information from near-Earth observation.

She was a frequent contributor to *Resources*, and we include excerpts of a number of her articles in a tribute in this issue. We also have collected remembrances from Molly's friends and colleagues, although this issue is not large enough to contain the outpouring in the weeks since her passing. Some others can be found at www.rff.org/rememberingMolly and in a special online issue of *Space Policy*.

As noted by Dick Schmalensee, chair of RFF's Board of Directors, Molly's unshakable belief in RFF's mission, work, and people was "both inspiring and contagious." As we work to make RFF an even more impactful institution, we go forward inspired by Molly's example. In that spirit, I also welcome your ideas for innovating and growing RFF, in collaboration, so that together we can strengthen both our environment and our economy. ●



RICHARD G. NEWELL
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Highlights from Recent Events at RFF

Policies to Price Carbon

“If we know that emissions up to x are particularly problematic but any emissions beyond x pass a tipping point at which a great deal of risk is involved, and we have uncertainty about what a [carbon] tax might do—then absolutely a cap-and-trade program providing for certainty with regards to emissions levels is exactly the right way to go. But that isn’t the situation we face in climate change. There is no clear and clean tipping point. So the classic argument for a cap-and-trade program doesn’t quite align with the problem we have today.”

Jerry Taylor, President, Niskanen Center;
March 2, 2016

Commodities and Deforestation

“The only way we will begin to address deforestation—the only way REDD+ will be successful on the ground—is if we throw every tool we have at this issue. Those tools involve governments, but they also involve changing how we source, how we finance big projects, and how money flows writ large. And that requires the types of coalitions that you see under the [Tropical Forest Alliance] 2020 and a lot of the emerging partnerships that you’re starting to see on the ground.”

Christine Dragisic, Foreign Affairs Officer,
REDD+ Focal Point, US Department of State;
April 6, 2016

Seafood Supply Chain Certification

“The US consumes about 15 percent of the total amount of global production of tiger shrimp in the Pacific ... [and] 8 percent of all of the Atlantic salmon farmed in the world. That’s not insignificant. It seems

logical that the NGOs would engage with the US companies to try to change their procurement practices, and hopefully that would lead to realizing improvement on the ground.”

Aaron A. McNevin, Director, Sustainable Food,
World Wildlife Fund; May 4, 2016

Local Oil and Gas Development Impacts

“Where we see tensions between locals and the state being the highest is where people who have land rights do not own the mineral rights. I would suggest looking at the EU wind policies that have integrated benefits with local governments; they have not seen as much local opposition to that type of energy development.”

Aliza Wasserman, Program Director,
Environment, Energy, and Transportation
Division, National Governors Association;
May 18, 2016

Coal Leasing on Federal Lands

“There is a strong case for reform here. It’s one that has many different parts that the administration is taking very seriously. Perhaps chief among them—at least most obvious and should be most noncontroversial among them—is a fair return to the taxpayers. On that ground, we’re falling well short, the system is antiquated, and the review that the Department of the Interior is doing is a very welcome and important step.”

Jason Furman, Chairman, White House Council
of Economic Advisers; June 22, 2016 ●

To view videos and presentations from these events,
visit www.rff.org/events.



Clockwise from top: Christine Dragisic at “Reducing Deforestation in Commodity Supply Chains”; Jason Furman at “The Economics of Coal Leasing on Federal Lands: Ensuring a Fair Return to Taxpayers”; Jerry Taylor at “Tax or Trade: Revisiting the Trade-Offs in Climate Policy Options”; Aaron A. McNevin at “Implications of Seafood Supply Chain Certification on Social Outcomes”; Aliza Wasserman at “How Oil and Gas Development Impacts Local Governments and Communities.”

Why California's Cap-and-Trade Program Works

DALLAS BURTRAW

When just 11 percent of available permits were sold at a recent auction of emissions allowances in California, detractors of the state's cap-and-trade program argued that it deserved a failing grade. To the contrary, California's cap-and-trade program has been working as designed and intended since its launch in early 2012.

Remember, the goal of a cap-and-trade program is to reduce pollution. Ideally, the economy would respond to such a program by using less fossil fuels and emitting less greenhouse gases—and that's what has been happening in California. In fact, carbon emissions are falling faster than anticipated, and the state has been lauded as an international leader in pioneering smart and workable environmental solutions that produce results. Ultimately, this means that the demand for emissions allowances decreases, which is what we've seen in the state.

So the reduction in demand for allowances observed in the recent auction is in part a result of the program's success. Other factors are state and local government companion policies that aim to reduce carbon emissions from specific technologies and recent uncertainty about the future of the program. Pending legal challenges cast doubt on the longevity of the program, further dampening the demand for emissions allowances.

Of course, a decline in the sales of emissions allowances also results in a decline in revenue that is directed to programs that reinforce the state's climate policy. For example, these missing revenues would fund

direct customer dividends in the electricity sector, energy efficiency programs for low-income households, and also California's high-speed rail. Although revenue is not the main goal of the cap-and-trade program, detractors have cited the decline in revenue as a failing. However, if the legislature wanted to fund these related programs, it could do so directly. Further, when uncertainty about the program's future is resolved, it is likely that revenues from allowance sales will bounce back. And if they don't, that means the emissions in the state have continued to fall. Who can argue with that kind of success?

Companion Climate Policies

California's climate policies that serve as companions to carbon pricing under cap and trade contribute importantly to achieving emissions reductions. These programs certainly deserve ongoing scrutiny to ensure that they are effective and not too expensive. So far, they not only have helped reduce emissions in the short run but also promote innovation and infrastructure investment in the long run by targeting activities that may not be responsive to carbon pricing policies. This is especially necessary and evident in sectors with substantial long-lived infrastructure requiring coordination and planning that are not triggered by a modest carbon price. Overall, such companion policies to carbon pricing as described below are imperative to achieving emissions reduction goals.

» **Renewables:** Whereas the concern in the electricity sector 15 years ago was that the cost of renewables might make even a 5 percent market penetration difficult, the current worry is about how to integrate

DALLAS BURTRAW is the Darius Gaskins Senior Fellow at RFF.

50 percent or more penetration—a nice problem to have. The issue of coordinating traditional and renewable electricity systems could not be seriously imagined or addressed until penetration of renewables became substantial. Today, the Renewable Portfolio Standard has made the role for renewables evident and revolutionized the future of the electricity system in California and throughout the West.

» **Fuels:** A moderate carbon price does not affect the life cycle impacts of transportation fuels or justify substantial investment in technology and new infrastructure, so the Low Carbon Fuel Standard addresses the long-run challenge of fuel innovation and infrastructure coordination. It provides an economic justification for research and deployment of electric vehicles and alternative liquid fuels. It also requires new infrastructure to be in place so that consumers can reliably change their transportation habits, incentivizing infrastructure investment.

» **Planning:** Electricity and transportation overlap through electrification of the transportation sector as well as land use planning and building standards to reduce transportation and electricity energy needs. The provisions of the Sustainable Communities and Climate Protection Act (SB 375) give incentives for local governments to incorporate greenhouse gas impacts in their long-run planning activities.

Spurring Infrastructure Development

Policies related to infrastructure development, such as creating a network of electric vehicle charging stations, promote innovation and initiate and guide strategic investments in California's low-carbon economy. Because of the persistent underpricing of climate change externalities, such policies are necessary to reinforce and amplify the signal given by the carbon price.

Infrastructure policies coupled with other narrowly prescribed measures and standards aimed at the performance of specific

technologies help shape the physical performance of the economy and alter the investment environment in the western United States. For example, funding for high-carbon projects is more expensive because those investments become more risky, and funding for innovative, low-carbon technologies becomes less expensive because of infrastructure-level policies.

Moving Ahead

In the end, California's cap-and-trade program works because it was designed well. It provides decisionmakers flexibility in choosing creative measures to reduce emissions, and it addresses long-term needs that support a healthy economy. It was crafted to include a price floor, or minimum price for emissions allowances, to help ensure the efficacy and stability of the program. (Note that some such programs, as in the European Union, were not designed with a price floor, and there unbridled falling prices have threatened the future of the carbon pricing mechanism.)

All existing carbon pricing programs today, including California's, rely on a carbon price that is well below the US government's social cost of carbon or the price that most economists think is necessary to spark a transformation of the economy. Yet California's cap-and-trade program, with its reliance on companion policies and focus on the future, is arguably the most well designed in the world and serves as a template for other new programs. ●

FURTHER READING

Burtraw, Dallas. 2016. The Fertile Middle Ground. Policy brief 16-05. Washington, DC: RFF.

Burtraw, Dallas. 2016. Forget Cap and Trade's Detractors, California's Carbon-Pricing Works. *Los Angeles Times*, June 23.

Burtraw, Dallas. 2016. To Lead on Climate California, Needs Its Whole Arsenal. *Sacramento Bee*, July 3.



Increasing Flood Insurance Take-Up for Economic Resilience

An Interview with Carolyn Kousky

RFF Fellow Carolyn Kousky and Resident Scholar Leonard Shabman have been exploring the role of disaster insurance in promoting household financial resilience to disasters. Kousky sat down with *Resources* to discuss their work on the topic.

RESOURCES: This is an interesting time to be talking about disaster insurance. We just had terrible flooding in Baton Rouge, and the media has reported that many of those flooded did not have insurance. Is this accurate?

CAROLYN KOUSKY: Unfortunately, it is often the case that many people don't buy disaster insurance. People in 100-year floodplains are required to purchase flood insurance if they have a mortgage from a federally backed or regulated lender, but in areas where it is voluntary, take-up rates are usually quite low. This is not just limited to floods; it's a pattern we see with many disaster risks. In California, the take-up rate of earthquake insurance is only about 10 percent.

Coverage for floods and earthquakes is not included in standard homeowners policies. Homeowners have to take out a separate policy. With floods, the vast majority of these are through the National Flood Insurance Program, but there is a small private market emerging.

RESOURCES: What will this mean for homeowners in Baton Rouge that did not have flood insurance?

KOUSKY: We have found that to be assured of the money needed to repair and rebuild, homeowners really need an insurance policy. If flooding is severe enough to trigger a disaster declaration, then the president can authorize spending from several Federal Emergency Management Agency programs. One is Public Assistance, which gives money to local governments to help with response and recovery. This is usually authorized. The president could also choose to authorize Individual Assistance, which provides aid to households. This is done in fewer than half the cases of a disaster declaration—but has been authorized for Baton Rouge.

Individual Assistance, in addition to providing help with immediate response, can give grants for repair and rebuilding. But these grants are capped at about \$32,000, and most recipients receive far less than this—on the order of a few thousand dollars. Of the awards made so far around Baton Rouge, the average grant is slightly more than \$5,000. The grants are only to make homes safe and habitable, not to bring them back to pre-disaster conditions. And the first line of assistance for homeowners is a loan from the US Small Business Administration. So, the aid to households is actually probably more limited than many people realize.

Now, sometimes Congress passes supple-

“Insurance often provides larger and timelier payouts than disaster aid.”

mental legislation and funds other disaster programs—as we saw after Hurricane Katrina and Superstorm Sandy. A notable program for households is the Community Development Block Grant program through the US Department of Housing and Urban Development. States and local governments received billions of dollars from this program after Sandy and have enormous flexibility in how they use those dollars. Some may channel them to homeowners for things like elevations or buyouts. But they also use the money for infrastructure, public buildings, businesses, and other things.

RESOURCES: So, disaster aid often falls short of homeowners' expectations.

KOUSKY: We have been making the argument that disaster insurance can be an important component to creating economic resilience to disasters for households and communities. One big reason is that insurance often provides larger and timelier payouts than disaster aid. And it reduces the post-disaster costs to households, so they do not need to use their savings or divert other spending to repairs. One study found that homeowners with insurance were more likely to rebuild, which can then limit negative multiplier effects in communities. Insurance also could be used as a tool to encourage investments in risk reduction, although targeted policies are also necessary.

All that said, insurance only provides those benefits if people are insured. There are multiple policy options that should be explored to expand the take-up rate for disaster insurance.

RESOURCES: What are some of those policy options? Are any of them already in place?

KOUSKY: There are a range of options, and we need to do more research to evaluate and compare them. One option would be to include all perils in homeowners policies, but there are some political barriers, as it likely would have to be done by each state individually. Another option that we already have investigated is the possibility of insuring entire communities. For example, a single policy purchased by a local governmental or quasi-governmental body could provide coverage to a large group of properties.

Other policies could address some of the reasons people may not buy disaster insurance, by improving the affordability of the policy, for example. Other reasons might have to do with lack of information or misunderstandings about insurance, the risk, or post-disaster policies. We also have done work showing that flood risk communication programs can be successfully designed if there is a better understanding of how individuals make decisions about these purchases. ●

FURTHER READING

Kousky, Carolyn, and Howard Kunreuther. 2014. Addressing Affordability in the National Flood Insurance Program. *Journal of Extreme Events* 1(1).

Kousky, Carolyn, and Leonard A. Shabman. 2015. Understanding Flood Risk Decisionmaking: Implications for Flood Risk Communication Program Design. Discussion paper 15-01. Washington, DC: RFF.

Kousky, Carolyn, and Leonard A. Shabman. 2015. *A Proposed Design for Community Flood Insurance*. Washington, DC: RFF



In Loving Memory of

**Molly K.
Macauley**

1957–2016

Anyone who had a meaningful interaction with Molly Macauley can cite many instances of personal kindness, support, and grace. For those of us fortunate to be her colleagues at RFF, those stories are literally countless. It was just who she was. The personal loss for all of us is devastating.

She was a bold and creative thinker, loved RFF, worked tirelessly to make it better, and had an unshakable belief in its mission and in the merit of every person in our organization.

Her loss is felt deeply in many communities, including the space policy community (whom she affectionately called her “space buddies”). Here, we have collected some tributes and remembrances from Molly’s friends and colleagues at RFF and beyond.

“Others will surely write about what a terrific person Molly Macauley was. Let me remind everyone what a clever researcher she was. As a callow graduate student, Molly recognized that, just as land in central business districts was generally much more valuable than that in the boondocks, so, too, were certain ‘parking spaces’ for communications satellites in the geostationary orbital arc more valuable than others. She traced out how the value of those spots fell as one moved away from the prime location(s). What a ‘cool’ and insightful idea!

We’ve all lost as good and supportive a colleague as anyone could hope for. But all of economics has lost one of its shining stars.”

Paul Portney, former President, RFF

“I admired Molly for her leadership, intellectual curiosity, and dynamism. She embraced new ideas, technology, and interdisciplinary methods. She took a comprehensive approach to Earth observations, helping us to understand the value of civil and commercial remote sensing as well as citizen-based observations.

I loved Molly for the person she was—

kind, compassionate, and genuine. Molly was a tireless mentor and advocate of early and mid-career women, including myself. She served on the scholarship committee for Women in Aerospace. She took many young women under her wing, offering wisdom and positive encouragement, and going the extra mile to recommend them for speaking roles at conferences or connecting them to her network. She was an inspiration and one of my dearest friends. I am infinitely grateful to have known her and will miss her dearly.”

Lea Shanley, Co-executive Director, South Big Data Innovation Hub, University of North Carolina at Chapel Hill

“I got to know Molly as Gilbert White Fellow, a visiting fellow, and a member of the External Faculty Review Committee for RFF. Largely because of our relationship, Michigan undergraduates became RFF interns, RFF interns became Michigan graduate students, and Michigan graduate students became RFF fellows. Soon after we met, Molly and I coauthored two papers on landfills (with Eduardo Ley). Twenty-four years later, she lacked time to coauthor but her thoughtful questions and encouraging manner continued to influence my research. My last memory of Molly was of her chairing the RFF equivalent of a faculty meeting—completely conversant with each colleague’s research. How unlike academia! Molly’s loss is both painful and beyond my comprehension.”

Stephen W. Salant, Research Professor, University of Michigan; and Visiting Fellow, RFF

“Molly loved RFF and was always so gracious and thankful for everyone. I often received emails of thanks for certain things that I did for her. Even if she was rushing to or from a meeting or to an event, she always asked me how I was doing and how things

were. She was a bright, driven, and sweet person. She had a strong affiliation with NASA and space programs, so when major space news broke I would often talk with her about things. She always seemed to have a smile on her face and mentored our staff members in many ways. She did wonders for our organization and research program. RFF is not the same without her, but I know that she would want the best for RFF going forward.”

Mike Brewer, Mailroom and Purchasing Assistant, RFF

“ Even before Molly completed graduate study, recommendations for her as a potential RFF employee could be summarized as: ‘special.’

Molly’s attitude about the purpose and method of RFF is captured by the same word—special. ‘Special’ describes Molly’s connection to, and regard for, those with whom she associated, personally and professionally.

Molly’s belief in the importance of new horizons for RFF research was special indeed. Molly believed RFF would create ‘resources for the future’ as it explored unknown frontiers with special research. Molly was special to us all, as vice president for research at Resources for the Future and beyond.”

Emery Castle, Professor Emeritus, Oregon State University; and former President, RFF

“ Molly Macauley was an economist of the first order, whose interests ranged across a wide range of human activities, not just space, but environmental protection, remediation, and conservation. It seemed particularly apt that much of Molly’s career was at Resources for the Future. Her work focused on ensuring resources for the future, whether natural resources and the Earth’s

environment, or the information, resources, and energy potentially available from space. Molly’s work and mentoring created bridges between requirements for rigorous, quantitative analysis and an understanding of the emotional and sometimes romantic motivations for space and environmental activities. We are all the poorer for her passing and all the richer for her work.”

Scott Pace, Director, Space Policy Institute, George Washington University

“ When Molly became RFF’s Vice President for Research, she took up the task with gusto, dedication, and humility. She was eager to lead, but only if she could lead well. During the recruitment process, she undertook a major research project into leadership, learning from every available source—from books to professional colleagues. She confessed that she had limited experience with team leadership and regularly evaluated her progress in growing into an effective leader, which she certainly achieved.

She and I met nearly every other week to discuss institutional developments and challenges. It was quickly apparent that she adhered to high standards of scholarship and personal integrity and cared deeply about RFF personnel. She exhibited kindness and respect for RFF scholars and high expectations for their work. She was determined that RFF should make major contributions in helping society meet its environmental and resource challenges.

In her professional life, she unquestionably made such contributions—which she never would have acknowledged. But perhaps her greatest contribution was the exemplary character she modeled for us to follow.”

Phil Sharp, Fellow, Center on Global Energy Policy, Columbia University; and former President, RFF

In Her Own Words

Molly was a frequent Resources contributor, and her pieces opened our eyes to new possibilities for learning about the natural world, opportunities to apply economic principles to space policy, and burgeoning environmental problems on Earth and beyond. We've collected excerpts from some of those articles here, attempting to give a glimpse at the breadth, creativity, and razor-sharp intellect that we all admired in Molly.

On Environmental Protection in Space
Landing a robot on the surface of a planet to look for evidence of life automatically introduces our own germs into that planet's environment. The microbe we find on Mars may be our own.

How might planetary exploration go forward? Protecting planets and other celestial bodies while exploring space requires the balancing of competing objectives, wholly analogous to the tradeoffs involved in environmental protection on Earth. An example is zoning. On some planets, researchers have identified special regions where there is a high potential for the existence of indigenous life, such as where liquid water may be present. International protocols now require additional sterilization requirements for spacecraft making contact in these zones.

—“Space as the Canonical ‘Global Commons’: An Introduction to Its Economics,” *Resources* 168, 2008

On Long-Lasting Environmental Pollution

The intergenerational nature of “forever-ours” problems strains the capacity of effective governance. Most governing institutions are subject to harsh myopic pressures. Regulators are stretched thin by the short-run pressures of fiscal year budgets and immediate concerns. This problem

of managing some types of intergenerational environmental issues suggests that the nation may benefit from institutional innovation in capacity to think long term—maybe something like a “science court.” Might a Supreme Court for Intergenerational Resource Allocation make sense?

—“Forever Ours? The Challenges of Long-Lived Environmental Problems,” *Resources* 185, 2014

On the Value of Information Related to Climate Change

The specter of tipping points raises additional questions about the provision of information if, despite best efforts, society is unable to adapt to abrupt changes in climate. What information is required to monitor the approach of possible extreme changes in climate? How early is early enough for action to be taken? At present, no US agency has the responsibility to ask and answer questions such as these, despite their relevance to long-term thinking about both adaptation and our recourse if our best efforts to adapt fall short.

—“Investing in Information to Respond to a Changing Climate,” *Resources* 178, 2011

On the Promise of Drones

Drones are low cost and offer an unmatched ability to acquire critical data for understanding our planet and the effect of humans on it. Perhaps most interesting is the romance of the drone: it enables ordinary people to see, explore, and appreciate nature and the environment in new ways. Regulators should not lose sight of these benefits in designing rules to promote the safe and nonintrusive use of this evolving and promising technology.

—“Data from Drones: A New Way to See the Natural World” (with Timothy Brennan), *Resources* 192, 2016

On Virtual Mapping Tools

For thousands of years, maps and the sense of distance they connote have contributed a spatial dimension to places unknown. But today's technology enables us to "virtually" be anywhere, under nearly any condition or scenario. Tools such as Virtual Earth, Google Maps, and Geographic Information Systems (GIS) software have moved map making from the province of cartographers to anyone with access to a laptop or cell phone. These and other tools allow Earth science data and social science information to be combined with traditional maps. And merged with photos and three-dimensional, often near-time dynamic renderings, these maps allow us to virtually be in places we may never visit. We can walk around and explore or see the effects of proposed activities—say, pesticide applications that affect runoff transported to a watershed hundreds of miles away.

This ability to communicate remotely sensed information about the ecosystem, both in 2D form and in the "I am there" feeling of 3D, will enable us to both measure and understand ecosystem services much more effectively.

—"New Opportunities to 'See' Our Environmental Relationships" (with William B. Gail and Shalini P. Vajjhala), *Resources* 165, 2007

On Regulating Space Debris

To be effective, debris mitigation actions will probably require the consensus of those currently using space, those who will be using space in the future, and those who may never use space directly but who benefit indirectly from space activity. If the record of global environmental cooperation on Earth is any blueprint, however, reaching consensus on space debris policy may require an explicit resolution of the poten-

tial clash between environmental protection of space and the development of spacefaring capability by nations not presently active in space.

—"In Pursuit of a Sustainable Space Environment: Economic Issues in Regulating Space Debris," *Resources* 112, 1993

On Allocating Resources on the International Space Station

The use of prices to allocate station resources may be the most effective mechanism for allowing station users to assemble the best set of resources in the most efficient quantities and at the right time. The relative scarcity of a multitude of resources can be arbitrated by prices. ... [U]nlike the tendency of administrative rationing to become politicized, prices operate without partisanship.

—"Decision Time for Allocating Resources on the Space Station," *Resources* 89, Fall 1987

On the Pricing of Remote-Sensing Data from Space

The pricing of remote-sensing data at short-run marginal cost could make remote sensing from space financially unsustainable and could limit the potential of private operators to profit from the provision of these data. ...

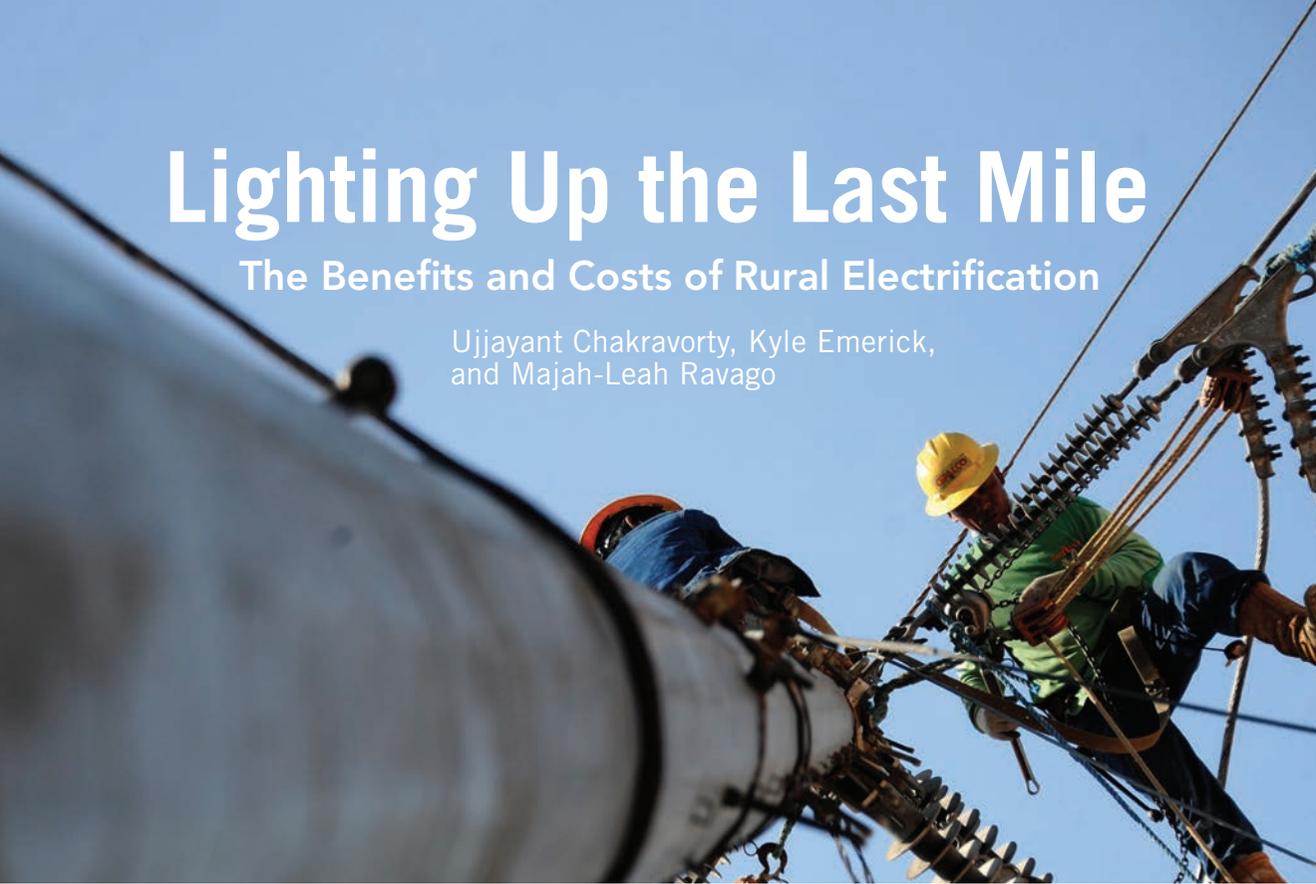
To avoid undue entry limits and provide for cost recovery, prices should be set so that on average they recover the long-run cost, including capital replacement charges, of the data provision services. Where prices are set above marginal cost to recover fixed expenses, users making the least flexible demands should pay relatively more in order to minimize distortions on the demand side.

—"Remote Sensing of Earth from Space: Economic and Policy Issues" (with Michael A. Toman), *Resources* 107, Spring 1992 ●

Lighting Up the Last Mile

The Benefits and Costs of Rural Electrification

Ujjayant Chakravorty, Kyle Emerick,
and Majah-Leah Ravago



Approximately one in seven people in the world are still without access to electricity, according to the World Bank. In many countries, the regions that remain to be electrified are remote, and providing electric connections to the mostly poor people living in these areas is cost-prohibitive.

At the same time, decisions about whether and how to expand electricity access—which can trigger significant changes in the economy—are being made in the absence of rigorous empirical evidence of the potential economic benefits. If policymakers are to make informed decisions on which communities should be targeted for grid connections—and what financing and other incentives need to be provided to facilitate access—we need to accurately estimate both benefits and costs in the same setting. Until now, no such studies have compared the realized benefits of connecting households to the grid with the costs of providing them with electricity.

To fill this gap, we examined the effect of

rural electrification in the Philippines from 2003 to 2014 on household income and spending and compared that with data on actual electrification costs provided by the Philippine government. The resulting short-term benefits are so substantial that the relatively high costs of infrastructure were recovered in just one year, on average.

Electrification in the Philippines

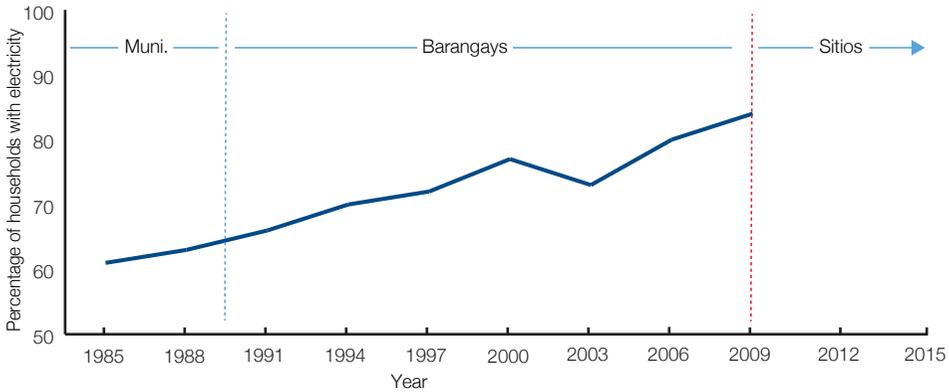
The Philippines is a middle-income country with roughly 100 million people spread over more than 7,000 islands. Figure 1 shows the evolution of electrification over time. Until 1986, the focus was on the electrification of municipalities, often in urbanized areas. As a result, only 60 percent of households had

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Figure 1. Evolution of the Household Electrification Rate in the Philippines



Note: Until the year 1990, municipalities were electrified. Villages, or “barangays,” came next, during 1990–2009. Efforts since 2009 are focused on electrifying neighborhoods, or “sitios,” within barangays.

Source: Family Income and Expenditure Survey, Philippine Statistics Authority.

access to electricity in 1985.

The rate of electrification rose steadily during the next two decades with each successive leadership regime. The household connection rate increased to 73 percent by 2003—with the focus shifting toward electrifying villages, or “barangays,” under the Barangay Electrification Program.

During 2004–2009, electricity was rolled out to the final 10 percent of rural villages (or as we call it, the “last mile”). While all villages were connected by 2009, around 15 percent of households were still not connected. That is, electrifying a barangay does not imply that all households in it have immediate access to electricity. Programs such as the Sitio Electrification Program and the Barangay Line Enhancement Program have helped extend grid infrastructure to neighborhoods and villages that previously relied on off-grid sources, such as solar panels. Currently, rural electric cooperatives, similar to US programs in the 1930s, are responsible for implementing electrification programs in their jurisdictions.

Electricity in the Philippines is expensive. In 2014, the average price across all electricity providers in the country was about US\$0.20 per kilowatt hour—nearly double the retail price in the United States and

higher than in many other developed countries. In addition to prices, supply reliability is problematic, largely due to the frequency of severe typhoons. Our estimated impacts of electricity are conditional on both of these factors.

Large Welfare Gains to Rural Electrification

To study the benefits of bringing electricity to the “last mile,” we projected the expansion of electricity to the final 10 percent of barangays, under the assumption that the first villages to be connected are those that are closest to the existing electricity grid. This approach generates a rank ordering of the villages to be electrified over time.

We found that the arrival of electricity in a village causes total household expenditures to increase by 38 percent. Similarly, total household income increases by nearly 42 percent. These large effects arise even though, on average, only 23 percent of the households in the village are electrified at first—that is, not all households connect to the grid immediately upon electrification.

By using cost data from the ongoing Barangay Line Enhancement Program, we find that it costs roughly \$325 per household to bring electricity to the median village in

our sample. Mainly, these costs include the physical costs of electricity poles, wires, and installation labor. Household expenditures in fuel and electricity increase. However, any decreases in expenditures on traditional lighting sources, such as kerosene, are more than set off by increased spending on electricity, which is not surprising given the high cost of electricity in the Philippines. The total cost of electrification per household is approximately \$615.

Combining the costs and benefits figures, our data suggest that the physical infrastructure costs of extending the electricity grid to a village are, on average, recovered after just a single year of realized welfare gains.

The Role of Agricultural Income

What explains these welfare gains? One popular theory is that the arrival of electricity allows the household to reallocate labor away from household tasks and toward formal wage labor. Yet we find that the effect of predicted electrification on labor force participation is small and statistically insignificant.

Instead, our analysis suggests that self-employment—particularly agricultural income—accounts for a disproportionate share of the gains from electrification. About 92 percent of households in our sample earn self-employment income, mainly from agriculture. Predicted electricity leads to an approximate 22 percent increase in agricultural income.

We are not able to pinpoint exactly how agricultural activities benefit from electricity—for instance, whether electricity facilitates irrigation or makes it possible for farmers to mechanize post-harvest operations, such as crop threshing. But our results do show that electricity is being used as an input to agricultural production and suggest that early adopters within the village may be energy-constrained. In such cases, benefits from extending the grid may dominate off-grid options, which offer low voltage and

“Our data suggest that the physical infrastructure costs of extending the electricity grid to a village are, on average, recovered after just a single year of realized welfare gains.”

are therefore limited in their usage, especially in driving farm machinery or irrigation equipment. By the same token, late adopters in the village may be those with lower endowments of complementary productive inputs (for example, land and credit) and are prone to using electricity for consumptive purposes. However, further research is necessary to rigorously establish the different settings, as well as causal mechanisms that generate such large welfare estimates.

These findings have significant policy implications for governments weighing the benefits and costs of alternative investment options for developing infrastructure. At the same time, decisions on how to provide electricity to these mostly poor communities living in remote locations have global implications. On the one hand, provision of high-voltage on-grid access will likely mean reliance on fossil fuel-based power generation with large environmental externalities in the form of greenhouse gas emissions. On the other, off-grid, low-voltage sources (such as home solar systems) may provide fewer benefits to households. ●

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Water Conservation Policies: Prices versus Restrictions

Casey J. Wichman

Economists love prices. But at what cost, theoretically, are we willing to raise the price of water to manage demand during periods of drought?

In the context of residential water policy, raising prices to encourage conservation is an attractive option for several reasons. First, in the face of a price increase, people have complete flexibility on how and where to use their water. For example, individuals who are most willing to forgo planting a vegetable garden in a given year will reduce consumption before those who just resodded their lawns. Second, a regulator doesn't need to know who is most willing to reduce usage, since markets have a way of handling that on their own. Third, for inelastic economic goods with essentially no direct substitute—like water—price increases lead to increases in revenue, which is a good thing for water utilities that desperately need to invest in new water infrastructure.

However, using prices to manage water consumption has its downsides, too. For

one, it is difficult to engender the political support to raise water prices in an agile manner. Municipal water utilities in the United States often are regulated by utility commissions that make even annual rate increases a months-long process. Another issue is that access to basic water is seen as a human right, which makes pricing water as a commodity a delicate task.

My colleagues Laura Taylor and Roger von Haefen (of North Carolina State University) and I uncovered relative effects of price and nonprice policies for reducing household water use during the 2007 drought in North Carolina—one of the most severe in the state's history. Using household-level consumption data for over 1,700 households in six municipalities across the state, we compared responses to price changes and voluntary and mandatory outdoor watering restrictions along several household and sociodemographic characteristics.

Unsurprisingly, we found relatively lower-income households to be the most sensitive to changes in price in our sample (due in

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part to aggressive drought pricing strategies in Chapel Hill, for example). This result occurs because water bills comprise a larger portion of monthly expenditures for lower-income households than others in our sample. At the other end of the price-responsiveness spectrum, we find that the households with in-ground irrigation systems do not respond to price increases in a meaningful way.

But what happens if your water utility asks you nicely to reduce consumption by, say, suggesting that you water your lawn only on certain days of the week? We found that voluntary policies implemented within our study's time frame induced an 8 percent reduction in consumption on average. Further, there is virtually no differential response by income level, but here again we see a difference for households with in-ground irrigation systems. It appears that voluntary policies are not a large enough "stick" to encourage households to turn off their sprinklers.

Cue the larger stick—a mandatory policy—that bars almost all outdoor or extraneous water use with corresponding financial penalties: no turf irrigation, no car washing, and very limited watering of vegetable gardens. These restrictions were implemented during the most severe period of the 2007 drought. The result? Within our sample, we saw a nearly 13 percent decrease in aggregate water consumption, with almost uniform decreases across income groups. Further, our analysis reveals that households with irrigation systems and historically high consumption patterns reduced consumption by over 20 percent in some cities. That is, the mandatory policy effectively reduced consumption among the biggest water users while remaining equitable across households with different incomes. This is nearly the polar opposite of what we see with price changes.

Does this mean prices don't have a role in water conservation policy? Surely I cannot affirm that statement and maintain

“We need smarter pricing systems; simply raising prices won't do the trick.”

credibility as an economist. The pros of price-based mechanisms, mentioned above, are real. But we need smarter pricing systems; simply raising prices won't do the trick. In our analysis, achieving the same reduction in consumption induced by mandatory policies would an increase of more than 50 percent in the average price of water.

So, what does smarter water pricing look like? We can start by rethinking the role of price in water demand with all of the tools at our disposal. First, we need to raise the price of water to reflect its full value to society, including the cost of provision for consumption and the opportunity cost of other uses of water supplies. Full stop. We can manage distributional issues by rebating some of the revenue from higher prices to low-income households. We can construct rates that allot a certain “water budget” to households based on their expected consumption. And we can make water prices and consumption much more salient for households by using newer metering technology or billing consumers more frequently. In fact, water utilities across the country are already implementing these practices. But until these practices gain popular support among suppliers and consumers alike, policy sticks seem to be an attractive second-best solution. ●

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Protecting Our National Parks

New Entrance Fees
Can Help

America's national parks have been blessed—and cursed—with an overwhelming number of visitors in recent years.

Margaret A. Walls

This year, the National Park Service turned 100. In celebration of this anniversary, entrance fees were waived at all parks during National Park Week in April.

The promotion was one of the many ways that the Park Service and its partner, the National Park Foundation, have been encouraging people to get out and enjoy “America’s Best Idea,” the subtitle of Ken Burns’s popular nine-part PBS miniseries on the history of the national parks. In recent years, the agency has started its Every Kid in a Park program, which provides free annual passes to fourth graders and is one of several efforts to get children out into nature. Another program, Find Your Park, encourages all Americans to visit the parks and then share their stories and photos, which are eligible for prizes and other recognition.

Increasing Visitors: A Blessing and a Curse

The parks have been blessed, and cursed, with an overwhelming number of visitors in recent years—a record 307 million in 2015. After many years in which visitation stayed relatively constant, many parks have seen increases of 20 to 25 percent over the past 10 years. But the Park Service may be a victim of its own success.

This growth in popularity has led to overcrowding, especially during the peak summer season. Zion National Park in Utah restricted access to cars 15 years ago in an effort to control congestion and reduce air pollution. But last summer, there were lines 300 deep for the shuttle bus that takes visitors into the park. Yellowstone allows cars but routinely experiences parking shortages as visitors fill lots and then park along roadways. Hikers are hard-pressed to find solitude on some trails in the “crown jewels” of the system, such as Grand

Canyon, Zion, and Yosemite, during the peak season. Cabins and rooms in lodges during the summer months in these popular parks are fully booked months in advance.

The Park Service is making some gentle suggestions to travelers to alleviate the problems. It is encouraging people to come to the parks during winter months or eschew the most popular parks and visit some of the lesser-known ones instead. It is also considering more Draconian long-term measures, such as daily limits on the number of visitors and a reservation system for entry.

Increasing Fees: An Efficient Approach

But the Park Service should be seriously considering a more efficient approach: changes in the pricing structure. Today, only 130 of the 411 sites managed by the agency charge entrance fees. The highest fee, in effect at Yosemite, Grand Teton, Yellowstone, Grand Canyon, and a few others, is currently \$30 per vehicle for seven days. An annual pass, which will get you into all national parks many times as you want to go, is \$60. For \$20 more, you can buy an America the Beautiful Pass, which gets you into any federal recreation site—not just national parks but also national wildlife refuges, national forests, and more. Senior citizens (age 62 and older) can get a lifetime pass to all sites for a mere \$10.

The Park Service has increased fees slightly in recent years. In summer 2015, the highest fee went up from \$25 to \$30. But the Senior Pass, which many observers—and even the director of the National Park Service—have argued is far too cheap, stayed the same, as did the America the Beautiful Pass. And changes always meet with resistance. There was some pushback to the increases last summer. A strong and often vocal contingent argues against price increases based on the idea that these are natural spaces owned by all Americans and they should be available to all Americans, not just those who are able to pay.

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I've made the case before that caution should be exercised when employing user fees to finance public goods such as parks. But that's because user fees ration use. When one person's visit to a park doesn't appreciably diminish the experience for others, the fee to use the park should be zero. That doesn't apply when the public good starts to experience congestion problems, and that's what's happening in some of our national parks. Rather than just suggest that people visit during the winter and go to alternative, less popular sites, the Park Service should incentivize such behavior through a differentiated fee structure based on season and location. That might mean a zero, or very low, cost during some seasons at some parks, but it means a significantly higher fee at the most popular parks during the summer months. And the \$10 lifetime Senior Pass needs

“The Park Service may be a victim of its own success.”

.....
to go. Seniors may be the most flexible in their travel plans and capable of shifting their time and location of visits. The Park Service should also consider charging a higher price to foreign visitors, who make up a large share of visitation at some parks. Many countries do this—Costa Rica, South Africa, and Kenya, to name a few.

Equity and accessibility are important issues, but an entrance fee is a tiny fraction of the overall cost of visiting a national park, most of which are located far from centers of population. For example, a family of four traveling from Chicago to the Grand Canyon is likely to incur costs



between \$1,500 (driving) and \$3,000 or more (flying) for a week's vacation. The \$30 entrance fee is a drop in the travel expense bucket. What's more, the experience itself is diminished if it is spent jostling with crowds on trails and in restaurants and parking lots or if the overcrowding leads to degradation of the resource, which has happened in some parks.

Funding Shortfalls in the Parks

Overcrowding is not the only problem the parks are facing that could be helped by a shift in the fee structure. The parks are in dire need of a cash infusion. The Park Service's deferred maintenance backlog sits at \$12 billion and includes serious problems with critical water and sewer systems, roads and bridges, and visitor centers, lodges, and other buildings. Grand Canyon and Yellowstone National Parks need costly upgrades to their drinking water systems and face total maintenance backlogs of \$372 million and \$604 million, respectively. Yosemite National Park has a backlog of \$555 million, much of which relates to its leaky sewer system. To address

“Rather than just suggest that people visit during the winter and go to alternative, less popular sites, the Park Service should incentivize such behavior through a differentiated fee structure based on season and location.”

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the problems, the Park Service is considering, for the first time, corporate sponsorships in the parks. The pros and cons of this approach are a subject for another day, but it is clear that new ways to raise money for the parks are on everyone's agenda. Raising entrance fees should be part of this larger conversation.



Data and Research Needs for a New Fee Structure

Figuring out an efficient and fair fee structure will not be easy. It requires detailed data on visitation, for starters, as well as analysis to shed light on price elasticities of demand for different groups of visitors at different locations. This means going beyond simple visitor counts to collection of sociodemographic information. It may also require some experimentation. For example, a multiyear pilot study in which some parks (a “treatment” group) adopt a seasonally differentiated pricing structure while other parks (the “control” group) maintain the status quo could provide useful information. Such an experiment would require careful study design and extensive data collection, but the Park Service could learn a great deal from it.

In recent years, the White House has pushed for evidence-based program evaluation across government agencies, leading to advances in education, health care, international aid, and other programs. The Park Service should be following in these footsteps.

The spotlight on the parks during this 100th anniversary year has illuminated the many problems the parks are facing. But the same spotlight has revealed that the American public places an incredibly high value on these unique natural resources. Changes in the structure of entrance fees will not provide a solution to all that ails the system—but it could be one part of the solution and help ensure that our national parks are available for another 100 years. ●

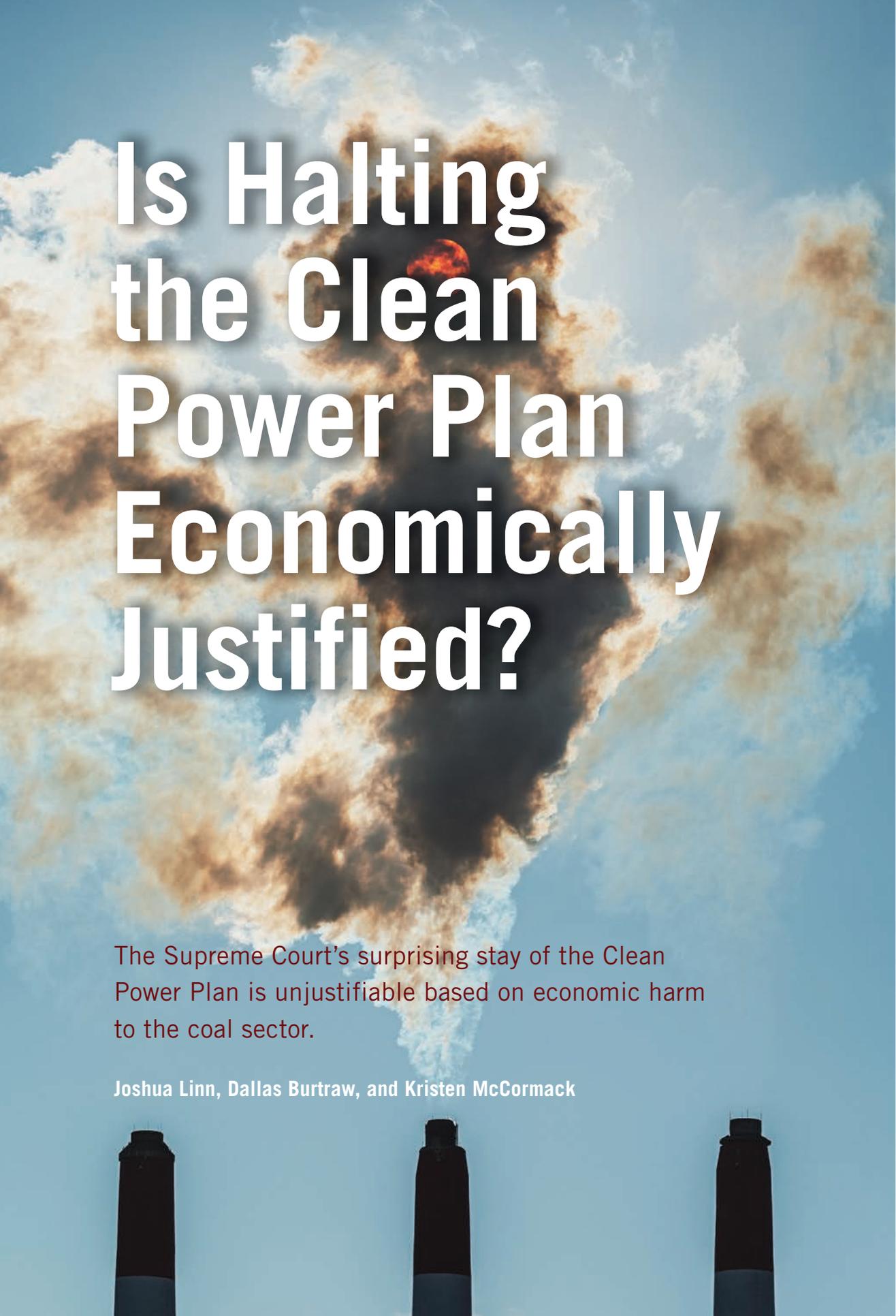
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Is Halting the Clean Power Plan Economically Justified?

The Supreme Court's surprising stay of the Clean Power Plan is unjustifiable based on economic harm to the coal sector.

Joshua Linn, Dallas Burtraw, and Kristen McCormack



The US Environmental Protection Agency's (EPA's) Clean Power Plan is one of the most significant and controversial climate policies of the Obama administration. Some argue that the plan takes an important step in demonstrating US leadership in addressing climate change and meeting the emissions reduction goals laid out in Paris. Others have sued EPA, arguing that the plan is an overreach of the agency's power and will significantly harm the US economy. In February, the Supreme Court halted implementation of the plan until the legal challenges are resolved.

The Supreme Court's action was highly unusual. It is uncommon for federal courts to block the implementation of a regulation while they decide the merits of the challenges, and it is even more unusual to grant a stay on a rule with compliance deadlines that are delayed for several years. To our knowledge, the Supreme Court has never before acted to freeze the implementation of a regulation after a federal appeals court has declined to do so (as the DC Circuit Court of Appeals did in January) and before the appeals court has completed its evaluation of the merits of challenges to the rule.

Legally, the burden of proof is on the challengers of a rule to demonstrate that a stay is justified. Requests for the stay cited potential harm to the coal sector, electricity consumers, and the broader economy, as well as to states developing their compliance plans. While the court did not publicly explain its action, one of the central arguments made in requests for a stay was that the plan would impose large, immediate, and irreparable costs to the coal sector. In new research, we find this reasoning to be economically unjustifiable.

The Clean Power Plan will lead to some retirements and shutdowns of individual coal-fired plants and coal mines. But the timing of these costs, which is central to the arguments made when requesting the stay, does not support the Supreme Court's decision.

The stay is justified based on harm to the coal sector only if costs:

- » occur during the period of litigation,
- » cannot be recovered later, and
- » are significant enough to threaten the existence of businesses.

Our analysis suggests that existing market, technology, and policy trends are already putting pressure on the coal sector. Because of these trends and the current compliance timeline, the Clean Power Plan will put minimal additional pressure on the coal sector for at least another decade, and the plan incorporates enough flexibility to allow businesses to delay any closures or other irreversible measures until well after the litigation period.

“The Clean Power Plan will continue to shift electricity generation away from coal, but it is by no means the most important source of pressure on the coal sector.”

Continuing Existing Trends

The Clean Power Plan will continue to shift electricity generation away from coal, but it is by no means the most important source of pressure on the coal sector. The electricity sector has been changing because of forces that predate the plan and likely overshadow it in importance.

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Since 2007, shale gas development in the United States has expanded, leading to lower natural gas prices. Between 2008 and 2012, the share of natural gas production that came from shale formations tripled, reducing the average delivered natural gas prices by about 60 percent during that time. The resulting shift from coal to natural gas-fired generation reduced overall carbon dioxide emissions by 13 percent, accounting for most of the total emissions reductions in the electricity sector between 2008 and 2013.

At the same time, the United States has experienced unprecedented growth in wind and solar energy. For example, investments in new wind-powered generators have caused wind's share of total electricity generation to increase tenfold, from 0.4 to 4.7 percent between 2005 and 2015. Policies supporting renewables and technological improvements largely explain this growth. In fact, most states now require a certain level of electricity generation from renewables.

The Clean Power Plan will continue the path of lower emissions. However, it will do so at a less rapid pace than has been observed in the last decade and at a lower cost to the coal sector than the cost of market and policy trends already underway. Our modeling shows that because of these trends, total compliance costs will be close to zero through the mid-2020s—and will be far outweighed by the public benefits of the policy.

Small Effects on Costs and Profitability

Most regulations have a combination of reversible and irreversible costs. To understand the nature of costs during the judicial review period, it is important to determine which of the costs imposed by the plan will be irreversible. Some decisions might be made during the review period to delay irreversible decisions until after judicial review is complete.

Importantly, the ultimate costs of the plan are not relevant in the decision to issue a stay. Whether coal-fired plants will retire or

“If the United States delays action, US leadership will be undermined, and other countries may follow.”

coal mines will shut down after the litigation is irrelevant. Irreparable harm during the course of judicial review can arise only in situations in which it would not be possible for the industry to take interim measures or postpone irreversible decisions.

Our modeling of the Clean Power Plan shows that although the plan will increase pressure on the coal sector, this pressure will not begin until about a decade from now. Until at least the mid-2020s, the plan will cause minimal decreases in coal consumption. The plan will not affect the profitability of coal-fired plants or coal mine production for some time, making it unlikely that irreversible costs attributable to the plan would occur during the litigation period.

Moreover, even if the rule required steeper emissions reductions at an earlier date than it actually does, plant owners would choose to delay any closures or retirements caused by the plan until the litigation is resolved. The Clean Power Plan does not require specific strategies to reduce emissions; instead, it provides flexibility to pursue the best strategies available. This flexibility and the timing of the rule allow states and the coal industry to delay decisions that cannot be undone, such as retiring a coal-fired plant, until well after the litigation period. The ability to delay these decisions means that claims of immediate and irreparable harm to the coal sector are unfounded. Thus, the Clean Power Plan does not meet the economic conditions for irreparable harm to the coal sector.

EPA provided seven years for preparation by states and regulated businesses



between the announcement of the finalized plan and the first required emissions reductions. Even if EPA had chosen a substantially compressed time frame and deeper emissions reductions, the power sector could still seek reversible strategies for reducing emissions, such as shifting coal- and natural gas-fired generation, which would allow it to delay irreversible decisions such as plant retirements.

Costly Delays

Some have questioned whether the deadlines affecting state compliance plans and the accompanying emissions reductions will (or should) be pushed back if the courts ultimately uphold the plan. The coal sector would benefit from such delays, in the short term, because costs could be pushed further into the future. However, as described previously, existing market, technological, and policy trends make such delays irrelevant to the coal sector for about a decade.

At the same time, delaying the deadlines would be costly to the public. Any additional pollution emissions that result would continue to contribute to global warming and harm local air quality. Perhaps even more important is the possible effect that a delay might have on international efforts to reduce greenhouse gas emissions. As one of the world's largest emitters of greenhouse gases, the United States has played a pivotal role in recent international momentum. If the United States delays action, US leadership will be undermined, and other countries may follow—magnifying the cost of the US delay and having a very real effect on the global climate. ●

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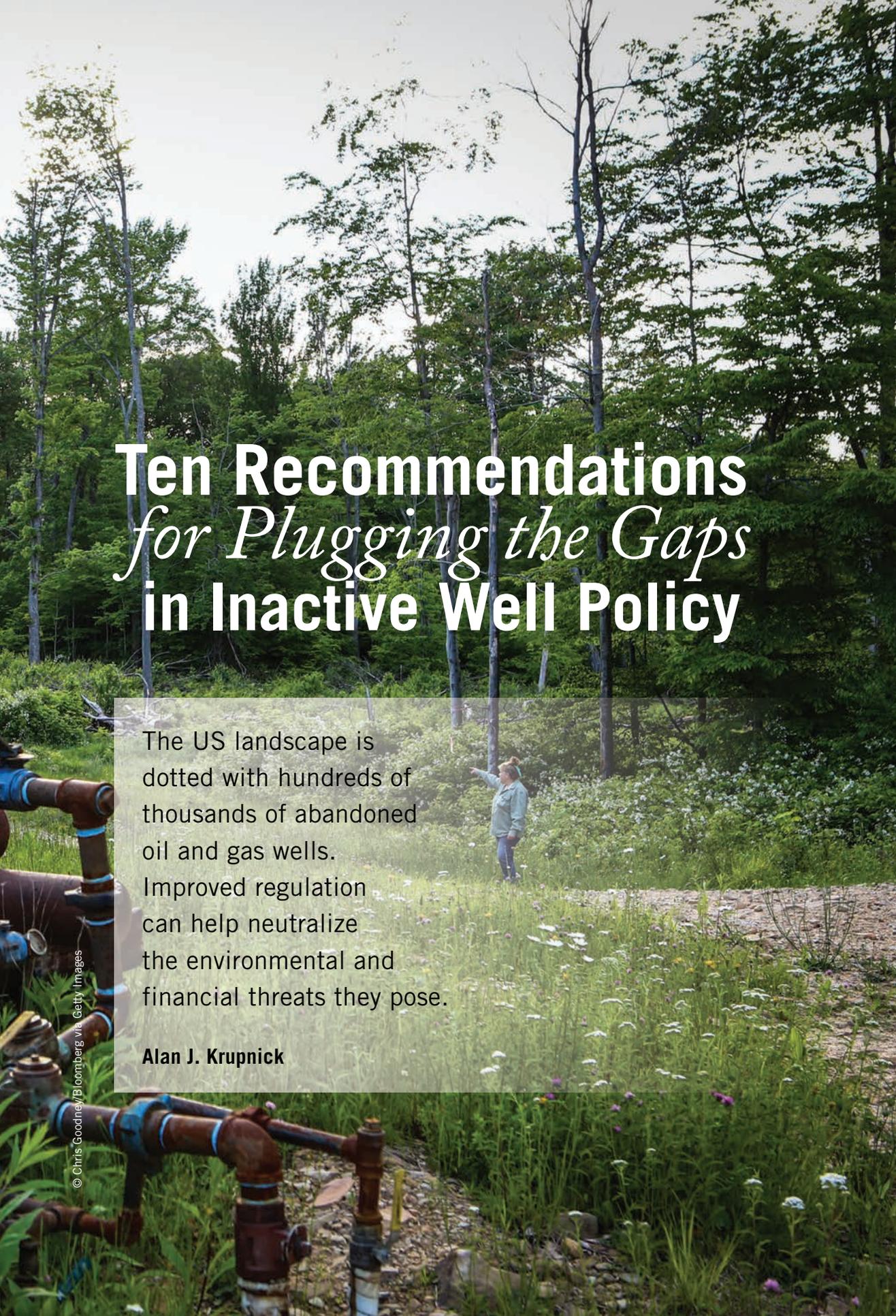
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Ten Recommendations *for Plugging the Gaps* in Inactive Well Policy

The US landscape is dotted with hundreds of thousands of abandoned oil and gas wells. Improved regulation can help neutralize the environmental and financial threats they pose.

Alan J. Krupnick

In places like Pennsylvania, where the first oil well was drilled in 1859, 100-year-old abandoned oil wells are part of the landscape, if you can find them. Some of these inactive wells are so old that they were originally plugged with dirt or lumber, and many of these older wells do not appear on official state records.

Today, of the at least 3.5 million oil and gas wells that have been drilled in North America, less than 25 percent are actively in production. The remaining wells are presumably left inactive, potentially threatening human and environmental health. These inactive wells can leak methane or contaminate nearby lakes, streams, and aquifers. Whether and to what extent even properly plugged wells can leak at some point in their existence are still open questions.

Significant financial concerns also exist about decommissioning inactive wells—that is, permanently plugging the wells and reclaiming the surrounding well sites. States face challenges with managing and decommissioning what are known as orphaned wells, those without a responsible owner. In recent research, my colleagues and I find that the costs of decommissioning these wells presents a large financial burden for states because the bond amounts required of well operators are generally too low to cover decommissioning costs, should a well owner become bankrupt or be otherwise unavailable to pay. Reforming the policies that govern well bonding, management, and monitoring can help mitigate the risks to states, the public, and the environment.

We have developed 10 policy recommendations with an eye toward reforming the regulation of onshore inactive wells in the United States. Lessons learned from this research and these recommendations will have implications that reach

“Inactive wells can leak methane or contaminate nearby lakes, streams, and aquifers.”

beyond the oil and gas industry, given that the challenge of ensuring that future environmental costs are borne by polluters is one that is common to other sectors, such as mining and waste disposal.

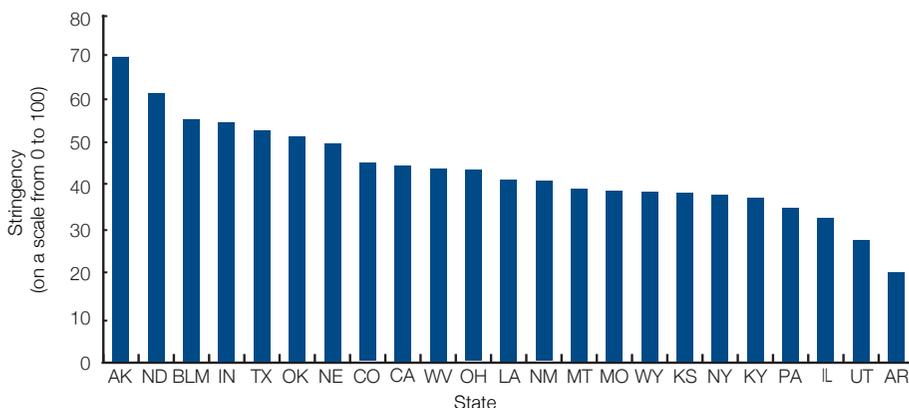
Liability and Decommissioning Costs

In an infographic in the Spring/Summer issue of *Resources* (no. 192), we compared the average cost of decommissioning inactive wells in 12 states with the average bond amount required and found that costs exceeded bond amounts in 10 of the 12 states. When the costs of decommissioning a well exceed the bond that operators provide to state regulators, the likelihood that the public will bear the costs of decommissioning increases, for a few reasons. Operators have an incentive to leave the well in temporary abandonment status rather than incur the costs of decommissioning. Wells may also be sold to operators that do not have the financial means to decommission these wells. Finally, if wells become orphaned, the revenue that regulators recover from industry bonds could be insufficient to cover decommissioning costs.

The difference between bonds and costs is likely to be even larger when considering wells that are covered by blanket bonds. In some jurisdictions, an operator may choose to file a blanket bond for all of its wells in the jurisdiction, rather than post individual bonds for each well. A blanket bond offers operators a quantity discount. For example, in Michigan—where 92 percent of decommissioning projects have costs that exceed the bond amount—regulators allow

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Figure 1. Stringency of Five Quantitative Regulatory Elements, by State and Bureau of Land Management (BLM)



operators to file a blanket bond for \$100,000 for a maximum of 100 wells that are less than 2,000 feet deep, whereas an individual well bond is \$10,000 per well. Individual well bonds for 100 wells at this cost totals \$1 million; however, a blanket bond for these 100 wells would cost only 10 percent of that amount.

The Stringency of Regulations

We also reviewed 31 regulatory elements (in 22 states) that influence the extent to which inactive wells will create an environmental or financial burden for the public. These regulations stipulate the types and amounts of bonds that operators can post, minimum requirements for wells to obtain temporary abandonment status, site reclamation requirements, and how inactive wells are to be monitored.

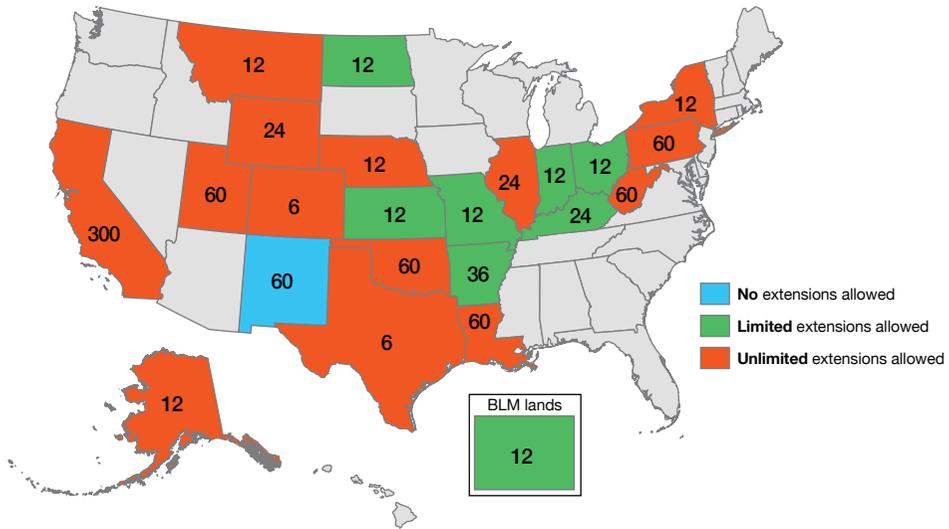
We find significant differences among states, although all states are addressing many of the elements in one way or another. We also compared federal regulations under the Bureau of Land Management (BLM) with those of the states and found that BLM regulations are generally more stringent than the regulations in most states. Figure 1 ranks states and BLM by the average stringency of five quantitative regulatory elements: minimum individual bond amounts, in dollars; minimum blanket bond amounts, in dollars; well idle

time, in months; duration of temporary abandonment, in months; and timing of reclamation requirements, in months. In the figure, each regulatory element is normalized such that the least and most stringent regulations receive a score of 0 and 100, respectively. Scores are then averaged with equal weights across the five elements. We find that Alaska ranks at the top, with North Dakota coming in second. Utah and Arkansas have the least stringent regulations for these elements. The fact that the highest stringency index is 70 (out of 100) implies that no state is regulating all five elements in the most stringent way.

There are interesting similarities and differences among the states. Almost all offer the option of blanket bonds. Requirements for temporary abandonment—including well testing and monitoring, proof of future economic viability, and mandated well closure requirements—are uncommon.

All the states we surveyed regulate the duration of temporary abandonment, where an operator may choose to stop production but not to permanently decommission the well. This means that operators can use temporary abandonment status to simply avoid or delay decommissioning costs even if the wells have very low future economic potential. Figure 2 shows how long wells are allowed to remain in temporary abandonment status in different states. This

Figure 2. Duration of Permissible Temporary Well Abandonment (months)



ranges from 6 months in Colorado and Texas to 300 months in California. All but New Mexico explicitly allow some form of extension of this status, either limited or unlimited. For example, North Dakota permits operators to apply for only one extension that lasts two years.

We also found that requirements for well plugging and site reclamation vary greatly in the amount of detail set forth in the regulations. This reflects both the different regulatory approaches taken by states and the fact that well plugging and abandonment requirements may be dealt with on a case-by-case basis with a large amount of regulator discretion. Whereas most states require preapproval of plugging plans, relatively few require inspection after plugging, and almost none require inspection (or even reporting or notification) after site reclamation is complete.

Ten Policy Recommendations for State Regulatory Reform

Based on our findings, we highlight a number of priority areas for policy reform for state oil and gas agencies, BLM, and other relevant agencies to consider.

Some recommendations do not apply to states that are already addressing these issues (or to BLM, when that is also the case). Such states can serve as a model for others. We use the term “states” to refer to all jurisdictions, including BLM. More detail on these recommendations can be found in our report and executive summary.

1. Compare bond amounts required of operators against decommissioning costs in each state and revise bonds accordingly to more closely approximate decommissioning costs.
2. Include provisions in bonding regulations to ensure that states do not bear the cost of particularly expensive decommissioning projects.
3. Calibrate bond amounts to account for a variety of factors that influence decommissioning costs, such as well depth.
4. Consider introducing surface damage agreements in addition to traditional plugging and reclamation agreements.
5. Tighten the conditions under which wells are allowed to be transferred from one operator to another.
6. Tighten requirements for maintaining temporary abandonment status.



7. Conduct legislative audits to evaluate the stringency of state monitoring efforts and the success of state plugging programs.

8. Develop more sustainable means for state financing of orphaned well decommissioning efforts.

9. Improve state reporting on the numbers of inactive wells of various types and statuses, costs, and how regulations are applied in the field and through permitting

10. Given the heterogeneity of state regulations, consider using the Regulatory Exchange (supported by the Groundwater Protection Council and the Interstate Oil and Gas Compact Commission) or other bodies to share regulatory information among states and learn from other states' experiences.

If implemented thoughtfully, these policy recommendations would help mitigate the environmental threat and financial burden posed by the population of inactive wells in

the United States, which will only continue to grow with the ongoing development of shale oil and gas resources. Ultimately, developing effective policies will depend on a deeper understanding of where the environmental and financial risks are greatest; how operators are currently making decisions about temporary abandonment, well transfers, types of bonds, and permanent decommissioning; and how regulations can best be reformed. ●

The authors thank the Paul G. Allen Family Foundation for supporting this project.

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Protecting against Invasive Species: A Risk-Based Approach to Live Plant Inspection

Targeting importers with higher records of infestation can reduce the introduction of invasive species through the international trade of live plants.

Rebecca Epanchin-Niell, Michael Springborn, and Amanda Lindsay

The importation of live plants to the United States has been expanding at a substantial rate, fueled by domestic demand for house and landscaping plants and low offshore production costs. In fact, since the mid-1970s, the dollar value of imported plants for cultivation has grown at an average rate of 68 percent per decade. However, these imported plants have long represented a primary pathway for the unintentional introduction of invasive pests and pathogens, which can “hitchhike” on imported goods with sometimes costly consequences. For example, the citrus long-horned beetle (*Anoplophora chinensis*) and white pine blister rust (*Cronartium ribicola*), both native to Asia, were introduced to the United States on live plants and have prompted expensive control campaigns. The citrus long-horned beetle attacks and kills a wide range of hardwood trees, including maple, oak, willow and poplar, as well as crop trees such as apple and citrus, and hence was the subject of a major—and fortunately successful—eradication campaign. White pine blister rust, meanwhile, continues to be the subject of major control efforts as it devastates ecologically and economically important white pine trees.

Inspecting imported goods is one way to reduce the introduction of invasive pests and pathogens and ensure the protection of domestic agriculture and natural resources. However, federal resources for inspecting live plant shipments have not grown at the same rate as imports. In 2011, the US Department of Agriculture’s Animal and Plant Health Inspection Service (APHIS)—which is tasked with minimizing the “entry, establishment, and spread of exotic plant pests, diseases, pathogens, and noxious

“Although the basic idea of risk-based inspections is simple—target riskier imports more intensively—designing the actual system is complicated by the involvement of thousands of producers.”

weeds”—proposed moving from a more uniform method of inspecting shipments of imported live plants to a risk-based approach that concentrates effort on imports with more problematic inspection histories. Although the basic idea of risk-based inspections is simple—target riskier imports more intensively—designing the actual system is complicated by the involvement of thousands of offshore producers, each likely to adapt its behavior to any change in the border inspection strategy.

In new research, we evaluate how to effectively design such an inspection program and find that relative to a uniform inspection policy, a risk-based inspection approach can cut the expected rate of infested shipments entering the United States by one-fifth—simply by reallocating existing resources.

Uniform versus Risk-Based Inspection of Live Plant Imports

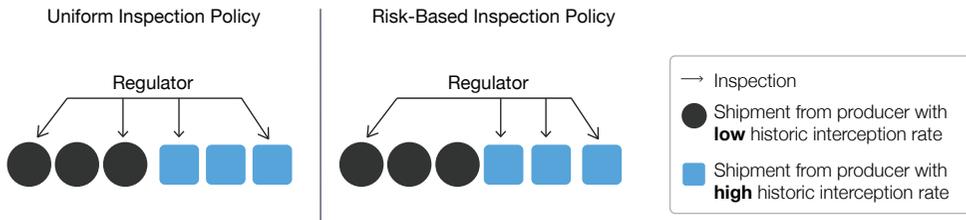
As part of its mission, APHIS inspects shipments of imported plant material at ports of entry across the country. This involves examining individual plants within a shipment for signs of pests or pest damage. Inspected shipments that are found to be infested—which we refer to as “intercepted” shipments—may be either treated, destroyed, or returned, imposing a cost on the producer and preventing pest entry into the United

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Figure 1. Uniform versus Risk-Based Inspection Procedures



States. When shipments are not intercepted, they continue on to their intended destinations.

APHIS differentiates shipments of live plants according to their type (that is, plant genus) and country of origin, and we refer to these unique combinations as “producers” of shipments.

Historically, APHIS has taken an essentially uniform approach, inspecting shipments from all producers at similar levels. In contrast, under a risk-based inspection policy, we consider a program in which producers are divided into medium- and high-risk groups based on their historic interception rates—a record characterizing previous inspection performance (Figure 1). Producers with a high historic interception rate are assigned to the high group and receive more frequent inspections than producers in the medium-risk group. Because historic interception rates are updated based on outcomes from recent inspections, producers move from the medium to high group and vice versa.

History of the Risk-Based Inspection Approach

Our analysis of risk-based inspection of live plant imports builds on a history of economic analysis. A model of a risk-based inspection policy was first applied to air pollution control problems by RFF’s Winston Harrington in 1988. In Harrington’s model, firms make the decision to “comply” or “violate” an emissions standard, and the regulator sets a policy in order to achieve a target compliance

rate with the lowest number of inspections. Firms are divided into high- and low-compliance groups, each with an assigned inspection frequency and fine for noncompliance. Firms with worse compliance records are subject to some combination of more intense inspection, greater penalties for violations, or tougher standards. However, firms can move between groups based on outcomes of recent inspections and an assumed set of transition rules.

Harrington found that a direct benefit of this type of targeted inspection policy is that incentives for cleaner activity are steered toward the dirtiest entities. An additional indirect incentive—known as “enforcement leverage”—is generated from the threat of moving into the high-inspection/high-penalty group or the prospect of escaping into the low-inspection/low-penalty group.

A Risk-Based Approach to Plant Inspection

A substantial policy design challenge is the allocation of inspection resources over a diverse set of imports to prevent entry of plant pests and pathogens. Conceptually, it is clear that a risk-based method for determining inspection intensity should provide gains when risks across shipments are not uniform. But several important questions arise: If shipments are to be categorized into groups based on historic risk, how should thresholds to distinguish group membership be established and how should inspection intensity differ between groups? How should these parameters be set to ensure that available inspection resources

are not overburdened? What monitoring structure generates the greatest incentive for offshore producers to engage in sufficient phytosanitary efforts? Finally, given that changing inspection policies is costly, what level of improvement in reducing pest and pathogen entry can be expected from a shift to risk-based sampling—in other words, do the costs outweigh the benefits?

We created a risk-based inspection model to answer these questions. In the model, the regulator announces a cutoff that determines how producers will be treated—those with interception rates above the cutoff are placed in the high-risk group with the remainder falling in the medium-risk group. The regulator also announces how inspection frequencies will differ between groups. Producers respond by choosing their level of effort to reduce infestations with the goal of minimizing their expected losses. These potential losses come from the costs of phytosanitary efforts, delays associated with shipment inspections, penalties for intercepted shipments, and the potential for a complete ban from the market if interception rates are extreme. So although phytosanitary efforts are costly, they reduce the anticipated level of all other losses.

A Cost-Effective Approach

Using our calibrated model of shipment inspections and producer responses, we find that producers indeed apply greater phytosanitary effort under a risk-based inspection policy than under a uniform inspection policy, regardless of whether they are in the medium- or high-risk group.

Although producers in the medium-risk group are inspected less frequently under a risk-based policy than under a policy with uniform inspection, they nonetheless have a stronger incentive to provide cleaner shipments to avoid being transferred into the high-risk inspection group. Producers in the high-risk group have the incentive to increase their phytosanitary efforts, both to reduce costs associated with

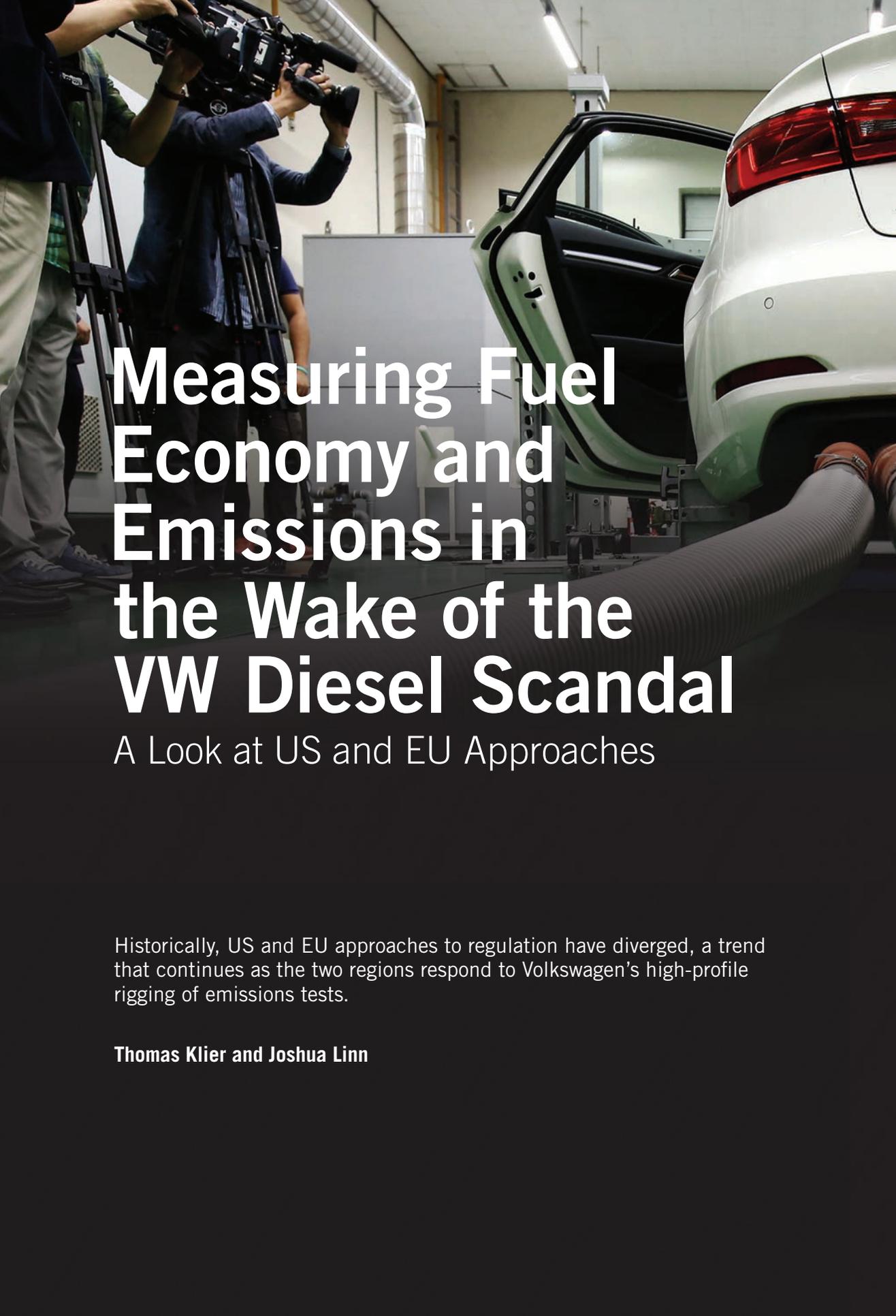
interceptions and to facilitate transition to the medium-risk group, which receives less frequent inspections. Additionally, producers just above the interception rate cutoff also increase their phytosanitary efforts to escape into the medium-risk group. This enforcement leverage—combined with the higher inspection frequency in the high-risk group—leads to reductions in the expected rate of infested shipments entering the United States.

To achieve the goal of minimizing the number of infested shipments entering the country given available inspection resources, just over half of the shipments (from the riskiest producers) fall into the high-risk, high-inspection group, and all of these shipments are inspected. In contrast, the remaining producers are placed in the medium-risk group, in which each shipment has just a 28 percent chance of being inspected. As noted, producers move between these groups as their interception history is updated over time.

We estimate that relative to uniform inspections, the optimal risk-based policy cuts the expected accepted infested shipment rate by one-fifth. This improvement is substantial, given that it simply involves reallocation of current inspection efforts. These gains are achieved by targeting shipments from producers with the worst interception records more intensively and incentivizing producers to clean up their shipments. Although the focus on inspection highlights the role of border interceptions in preventing pest introductions, in reality, reductions of accepted infested shipments resulting from inspection come mainly from incentivizing producers to clean up shipments at the source, and only secondarily from interceptions at the border. ●

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A photograph of a white car on a test rig in a laboratory. A camera operator is filming the car from the side. The car's rear door is open, and a large flexible hose is connected to the rear. The background shows industrial equipment and pipes.

Measuring Fuel Economy and Emissions in the Wake of the VW Diesel Scandal

A Look at US and EU Approaches

Historically, US and EU approaches to regulation have diverged, a trend that continues as the two regions respond to Volkswagen's high-profile rigging of emissions tests.

Thomas Klier and Joshua Linn



In September 2015, Volkswagen admitted to programming nearly 11 million vehicles—affecting the company's Volkswagen, Audi, and Porsche diesel models—to cheat on tailpipe emissions tests. The fallout included a historic \$15.3 billion settlement with consumers and regulators in the United States, affecting roughly 475,000 two-liter cars; a plunge in the company's market capitalization; and the threat of criminal charges. (The US regulator recently rejected VW's proposed fix for 85,000 three-liter engine cars sold in the United States.)

The scandal also affected the way regulators in the United States and the European Union approach fuel economy and vehicle emissions regulations, with different responses between the two regions. In

the United States, the US Environmental Protection Agency (EPA) has responded by tightening emissions testing procedures, whereas EU regulators are providing manufacturers more time to adjust to tighter standards. More broadly, comparing the regulatory approaches and procedures between the two markets shows not only that regulatory requirements can differ across markets but also that they can influence the choice of vehicle engines and fuels—in turn affecting the outcomes of environmental policy.

THOMAS KLIER is a senior economist and research advisor at the Federal Reserve Bank of Chicago.

JOSHUA LINN is a senior fellow at RFF.

For example, the diesel engine is a distinctly European approach to reducing vehicle carbon dioxide (CO₂) emissions. Compared with gasoline, diesel provides greater fuel economy, resulting in lower greenhouse gas and CO₂ emissions. Yet, relative to gasoline engines, diesel engines also tend to emit more nitrogen oxides and particulate matter, which contribute to the formation of smog. When Volkswagen's "clean diesel" strategy meant that some of its engines couldn't meet the stringent US tailpipe emissions rules without sacrificing performance, the company installed a device to circumvent lab tests without affecting performance.

The scandal will likely have broader implications for the regulation of vehicle fuel economy, greenhouse gas emissions, and emissions of other pollutants. In particular, some have suggested giving more weight to real-world testing of vehicles—that is, measuring emissions and fuel consumption from vehicles while on the road, possibly over their lifetimes and not just at the time of certification.

Background on US Regulations

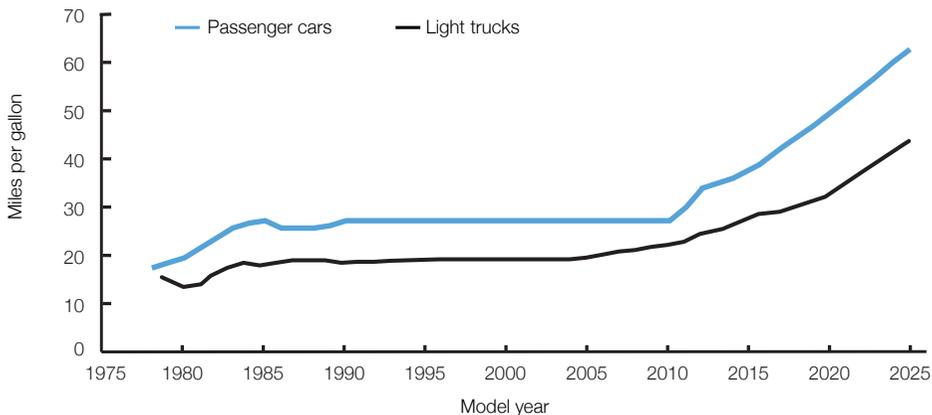
Well after particulate emissions were first addressed in the 1950s and 1960s, vehicle fuel economy became an important subject in the United States during the 1970s,

when oil prices spiked multiple times.

Congress enacted national corporate average fuel economy (CAFE) standards in 1975, requiring manufacturers to roughly double fuel economy by 1985, to 27.5 miles per gallon (mpg) for cars and to 19.5 mpg for light trucks. Fuel economy standards were tightened again in 2007, to an average of 35.5 mpg for cars and light trucks, to be achieved by 2016. In 2011, a new target of 54.5 mpg was set, to be met by 2025 (see Figure 1).

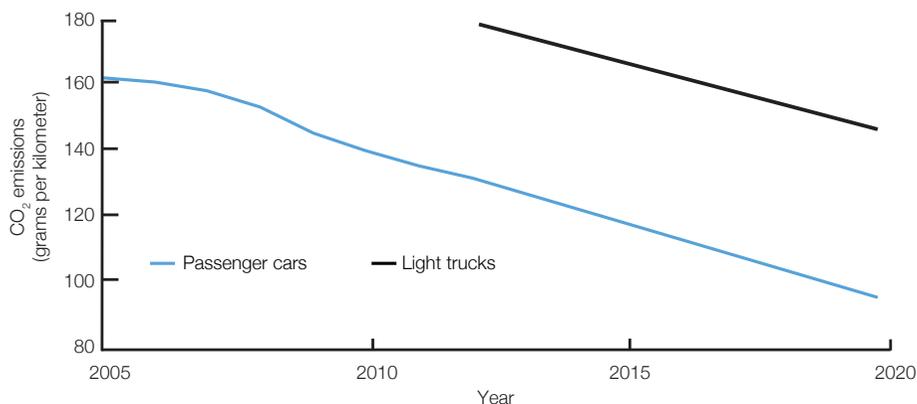
The rules for implementing fuel economy standards changed during the second CAFE regime, which began in 2007. The compliance mechanism has since been refined, and manufacturers now face standards that for both cars and light trucks are defined by the footprint of their vehicles (roughly the rectangle defined by the four wheels). Consequently, automakers that sell larger vehicles are subject to lower fuel economy requirements. According to research by RFF Fellow Benjamin Leard and colleagues, this relationship between a vehicle's footprint and its fuel economy requirement, along with the recent decline in gasoline prices (which caused consumers to shift toward larger vehicles), has slightly reduced the overall level of fuel economy required by the standards.

Figure 1. US Fuel Economy Standards



Source: McConville, Drew. 2012. *What the New Fuel Economy Standards Mean for You*. The White House Blog, August 30.

Figure 2. European Fuel Economy Standards



Source: International Council on Clean Transportation. 2014. *EU CO₂ Emission Standards for Passenger Cars and Light-Commercial Vehicles. Policy update.*

Background on EU Regulations

In the European Union, the regulatory goals of emissions and fuel economy were addressed in reverse order: fuel consumption came first. Numerous EU countries responded to the oil shocks of the 1970s by substantially raising fuel taxes to reduce fuel consumption. To this day, EU fuel taxes are much higher than those in the United States. Moreover, many EU countries decided to tax diesel at a lower rate than gasoline. Partly because of this favorable tax treatment, diesel's share among passenger cars in western Europe rose substantially, from 14 percent in 1990 to 52 percent in 2015, reducing fuel consumption.

In 1998, the European Commission reached an agreement with vehicle manufacturers to reduce CO₂ emissions by 25 percent by 2008, to 140 grams of CO₂ per kilometer (gCO₂/km, or about 40 mpg, which was more stringent than the US CAFE standards at the time). A mandatory requirement, backed by fines for noncompliance, was implemented in 2009; it set a level of 130 gCO₂/km to be met by 2015. Further tightening of regulations took place in 2012, including standards for light commercial vehicles. Passenger cars need to meet a CO₂ emissions target of 95 g/km (57.9 mpg) by

2021, and for light commercial vehicles it is 147 g/km (43.3 mpg) by 2020 (see Figure 2). Whereas the US standards depend on a vehicle's footprint, EU standards depend on its weight; heavier vehicles are subject to a higher CO₂ emissions (and lower fuel economy) requirement.

Compared with the United States, the European Union came late to regulating vehicle emissions of local air pollutants. It started with the Euro 1 requirements, which set nitrogen oxides emissions limits to 0.78 g/km in 1992. Catalytic converters were required in new cars in the European Union at the beginning of the 1990s, and the sale of leaded fuel was largely prohibited across the region by 2000.

The United States was ahead of the European Union by a decade on both counts. In the United States catalytic converters were ubiquitous in new cars by the early 1990s and leaded gasoline was nearly phased out entirely by 1990.

Currently the Euro 6 emissions rules are being implemented in Europe. These require emissions of nitrogen oxides in 2017 to be 90 percent below 1992 levels. Yet the new European emissions standards are less stringent than current US standards.

The Role of Compliance Tests

The large number of vehicles on the road makes direct measurement of emissions impractical. Instead, vehicle manufacturers play a key role in testing and reporting emissions. Each model year, new vehicles are tested in a laboratory where they are subjected to standardized protocols to be certified for sale. But the outcomes of those tests do not necessarily reflect real-life driving conditions.

In response, EPA adjusts the lab-based fuel economy ratings of vehicles so that the information communicated to US consumers better reflects actual driving conditions. Typically, the adjustment reduces the lab test results by about 20 percent, meaning that EPA estimates that the testing understates real-life fuel consumption. In addition, EPA conducts on-road testing of vehicles, both at low mileage (at least 10,000 miles) and at high mileage (more than 50,000 miles).

In the European Union, regulators pursue a similar testing approach, but EU tests tend to be less restrictive and currently do not include in-use testing. There is also evidence that the gap between the reported lab tests and real-world emissions has been growing. For example, the International Council on Clean Transportation (ICCT) reports a remarkable increase in the divergence between real-world and official CO₂ emissions values in the European Union from about 8 percent in 2001 to 40 percent in 2014. ICCT attributes the growing gap to manufacturers' more widespread exploitation of tolerances and flexibilities in test procedures to meet rising fuel economy requirements. Another study, also based on on-road testing, finds the average level of nitrogen oxides emissions from vehicles in the European Union to be seven times the certified Euro 6 emissions limit.

In the United States, several manufacturers recently have been fined for reporting incorrect testing data. For example, Hyundai and Kia were fined for overstating the fuel

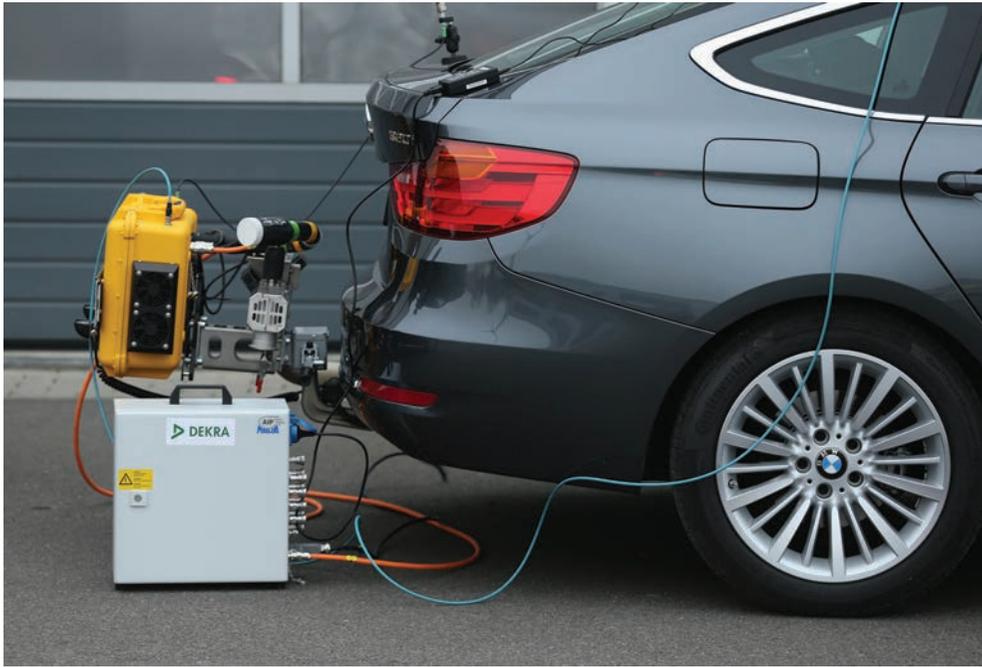
“In response to the VW diesel scandal, analysts have suggested giving more weight to the testing of vehicles under real-world driving conditions to make emissions testing more meaningful.”

economy on the majority of their 2012 and 2013 model year vehicles sold in the United States, and Ford had to restate the fuel economy of one of its hybrid vehicles in 2013.

The recent Volkswagen scandal dwarfs these previous cases, both in terms of lost sales for the offending company and in potential fines. In the 12 months prior to September 2015, diesel vehicles represented more than 13 percent of Volkswagen's US sales. The company has since been prohibited from selling any diesel vehicles in the United States. In response to the VW diesel scandal, analysts have suggested giving more weight to the testing of vehicles under real-world driving conditions to make emissions testing more meaningful.

Longer-Term Implications of the Volkswagen Scandal

Following Volkswagen's admission of circumventing emissions requirements, discussions have taken place on both sides of the Atlantic regarding test improvements to address the gap between lab-based test values and real-world observations. The different responses by US and EU regulators to the Volkswagen case thus far have partly arisen because of the European Union's greater reliance on diesel technology. In the United States, EPA has changed its



emissions certification procedure, adding several tests and more time to the process. In contrast, EU officials weakened the testing framework in response to widespread noncompliance with emissions standards in order to provide more time for the auto industry to adjust to the Euro 6 standards before those are fully applied. Accordingly, manufacturers will be allowed to exceed the nitrogen oxides emissions standard under real-world driving conditions by 110 percent between September 2017 and the start of 2020, and by 50 percent afterward.

Looking ahead, decisions about how to address environmental challenges will depend on local conditions and public sensitivities. For example, recent occurrences of smog in London and Paris may well have shifted the policy discussion in the European Union regarding the future role of diesel. In the United States, prior to the VW scandal, diesel fuel vehicles accounted for a small but growing share of the overall market. Whether more reliable testing or reputational damage affects the prospects of diesel vehicles over the long

term, in either region, is an open question. However, if diesel's market share were to fall, the auto industry's reliance on other technologies, such as hybrid and plug-in electric powertrains, would likely rise to meet the increasingly stringent greenhouse gas emissions and fuel economy standards. •

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Leard, Benjamin, Joshua Linn, and Virginia McConnell. 2016. Fuel Prices, New Vehicle Fuel Economy, and Implications for Attribute-Based Standards. Discussion paper 16-04. Washington, DC: RFF.

RFF Announces 2016–2017 Fellowship Recipients, Introduces New Fellow

RFF Awards 2016–2017 Fellowships

RFF is pleased to announce the following fellowship recipients to conduct environmental and energy research during the 2016–2017 academic year.

Joseph L. Fisher Doctoral Dissertation Fellowships

Joshua Blonz, a PhD candidate in agricultural and resource economics at the University of California, Berkeley, is studying the effects of time-varying electricity pricing and of energy efficiency upgrades for low-income households.

T. Robert Fetter, a PhD candidate in environmental policy at Duke University, is conducting research on information disclosure and the fracking industry.

John V. Krutilla Research Stipend

Catherine Hausman, an assistant professor at the University of Michigan, is using the stipend to support her research (in collaboration with RFF Visiting Fellow **Lucija Muehlenbachs** of the University of Calgary) on how rate-of-return regulation of natural gas local distribution companies affects gas leaks and spending to abate those leaks.

Walter O. Spofford, Jr. Memorial Internship Program

Zichao Yu, a PhD student in public policy and political science at Indiana University, worked with RFF Fellow **Zhongmin Wang** and others at RFF researching electricity sector reform in China.



RFF Introduces Fellow Daniel M. Sullivan

Daniel M. Sullivan joined RFF in summer 2016 as its newest fellow. His research

includes environmental, labor, health, and urban economics. In his own words, he describes his past, present, and future research interests:

“My interest in environmental economics started with an assignment in graduate school to replicate a published study on a cap-and-trade program. As I spent more time with the subject, I found more and more unique and important questions related to air pollution. That line of questions has brought me all the way to my current research.

My dissertation shows that current impact evaluations of air pollution may significantly understate the costs of pollution. This is because pollution levels spike around sources (power plants, for example) and are skewed by meteorological forces, especially the wind. This causes statistical problems when local pollution exposure is measured with metrics like ‘distance from a pollution source’ and average pollution monitor readings, metrics which are nearly universal in economics research. I show that more accurate measures of exposure based on the work of atmospheric chemists can lead to much larger estimated impacts. Specifically, I find that housing prices are almost 20 times more sensitive to air pollution than past research has found, implying that we may be dramatically underestimating how much society values clean air.

In the near future, my main research agenda is to further apply my new methods of evaluating the impact of air pollution. Specifically, I am looking at the effects of air pollution on local migration and gentrification, infant health, school attendance, and long-term academic performance.”

Awards and Appointments

RFF Board Member **Robert N. Stavins** of Harvard University received the 2016 Edmund G. “Pat” Brown Award, given by the California Council for Environmental and Economic Balance for his work on environmental policy research.

RFF Fellow **Yusuke Kuwayama** has agreed to serve on the Expert Council for the Environmental Stress Testing Project, launched by the Finance Initiative of the United Nations Environment Programme, the Global Canopy Programme, and the German International Cooperation, commissioned by the German Federal Ministry for Economic Cooperation and Development.

Karen L. Palmer, RFF research director and senior fellow, has accepted an invitation to serve on the American Economic Association Committee on Government Relations. This committee is charged with representing the interests of the economics profession in Washington, DC, and other locations around the country without taking a position on questions of economic policy or on any partisan matter.

The Harvard Environmental Economics Program awarded RFF’s newest fellow, **Daniel M. Sullivan**, the Enel Endowment Prize for the Best Paper by a Doctoral Student for his paper “The True Cost of Air Pollution: Evidence from House Prices and Migration.”

RFF University Fellow **Jesse Ausubel** has been selected to become one of the judges for the 100&Change competition, a MacArthur Foundation–sponsored grant competition to fund a single proposal that will make measurable progress toward solving a significant problem.

RFF Senior Fellow **Richard Morgenstern** has been awarded the Fulbright Chair at the University of Ottawa, where he will spend four months during 2016–2017.

RFF Senior Fellow **Allen Blackman** accepted an invitation to become co-director

(with Randy Bluffstone) of the Environment for Development Initiative Forest Collaborative, a network of researchers working on forest economics and policy.

Highlights from Recent Journal Articles by RFF Researchers

Economic Tools to Promote Transparency and Comparability in the Paris Agreement

Joseph Aldy, William Pizer, Massimo Tavoni, Lara Aleluia Reis, Keigo Akimoto, Geoffrey Blanford, Carlo Carraro, Leon E. Clarke, James Edmonds, Gokul C. Iyer, Haewon C. McJeon, Richard Richels, Steven Rose, and Fuminori Sano | *Nature Climate Change* 6(9) | September 2016

The Paris agreement culminates a six-year transition toward an international climate policy architecture based on parties submitting national pledges every five years. An important policy task will be to assess and compare these contributions. The authors use four integrated assessment models to produce metrics of pledges under the Paris agreement and show differentiated effort across countries: wealthier countries pledge to undertake greater emissions reductions with higher costs.

The pledges fall in the lower end of the distributions of the social cost of carbon and the cost-minimizing path to limiting warming to 2°C, suggesting insufficient global ambition in light of leaders’ climate goals. Countries’ marginal abatement costs vary by two orders of magnitude, illustrating that large efficiency gains are available through joint mitigation efforts and/or carbon price coordination. Marginal costs rise almost proportionally with income, but full policy costs reveal more complex regional patterns due to terms of trade effects.

Putting a Carbon Charge on Federal Coal: Legal and Economic Issues

Alan Krupnick, Joel Darmstadter, Nathan Richardson, and Katrina McLaughlin | *Environmental Law Reporter* 46(1) | July 2016

US policy to limit greenhouse gas emissions is driven, in part, by the US Environmental Protection Agency's proposed Clean Power Plan, which seeks a drop in carbon dioxide (CO₂) emissions from fossil-fueled power plants—a “downstream” approach to regulation. An alternative, or possibly complementary, approach is to consider the legal and economic feasibility of imposing an “upstream” CO₂ charge on coal production at its extraction site, and specifically on leased coal from federal lands managed by the Bureau of Land Management (BLM).

This article argues that BLM has the statutory and regulatory authority to impose such a charge, that it would be best to add it to the royalty rate, but that a large fee that dramatically reduced revenues could invite judicial concern. The economic case is weaker than the legal case because coal production on nonfederal lands would not be subject to the charge and so could ramp up in response to the new policy. Best would be a comprehensive set of charges on royalties for all fossil fuels, irrespective of ownership.

An Analysis of Costs and Health Co-Benefits for a US Power Plant Carbon Standard

Jonathan J. Buonocore, Kathleen F. Lambert, Dallas Burtraw, Samantha Sekar, and Charles T. Driscoll | *PLoS ONE* | June 2016

Reducing CO₂ emissions from power plants can have important “co-benefits” for public health by reducing emissions of air pollutants. The authors examine the costs and health co-benefits, in monetary terms, for a policy that resembles the US Environmental Protection Agency's Clean Power Plan. They then examine the spatial distribution of the co-benefits and costs, and

the implications of a range of cost assumptions in the implementation year of 2020. Nationwide, the total health co-benefits were US\$29 billion (2010\$), and net co-benefits under the central cost case were \$12 billion. Net co-benefits for this case in the implementation year were positive in 10 of the 14 regions studied. The results suggest that all but one region should experience positive net benefits within five years after implementation.

Optimal Management of Environmental Externalities with Time Lags and Uncertainty

Yusuke Kuwayama and Nicholas Brozović | *Environmental and Resource Economics* | May 2016

Many environmental externalities occur with time lags that can range from a few days to several centuries in length, and many of these externalities are also subject to uncertainty. In this article, the authors examine the key features of an optimal policy to manage environmental externalities that are both lagged and stochastic. They develop a two-period, two-polluter model and obtain closed-form solutions for optimal emissions levels under different combinations of damage functions and stochastic processes.

These solutions show that it is not obvious whether greater control should be exerted on polluters that generate externalities with longer lags or on polluters that generate externalities with shorter lags. The optimal ranking of polluters with respect to the length of the time lag associated with their externality will depend on the discount rate, conditional expectations of future states of the polluted resource, persistence of the pollutant, and initial conditions. ●

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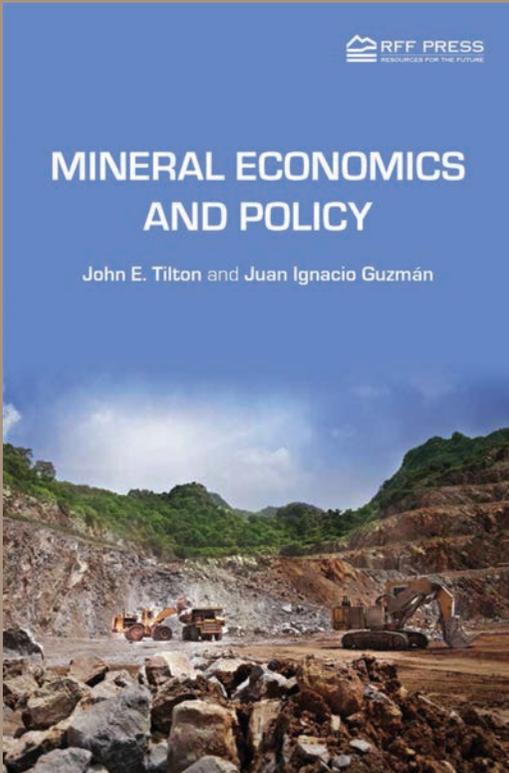


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