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Cover photo: Distributed energy resources, smart grid technologies, energy efficiency mandates, and new greenhouse gas regulations are transforming the US power sector. © Judith Green/Getty Images

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A Fond Farewell from Retiring RFF President Phil Sharp

My 11 years at RFF have only magnified my immense regard for this 64-year-old institution—its mission; its talented staff and board; its supporters; its high-quality, independent research; and its contribution to serious public discourse in our nation's capital and beyond.

Many commentators on the current state of American politics—the polarization and the discourse by tweet—have suggested a fading role for serious analysis and for think tanks. While there are significant challenges now in the public arena, I am convinced that the role for independent, rigorous analysis will remain vital, for several reasons.

First, despite current ideological battles in Congress and public debate, analyses by RFF experts today continue to feed into deliberations at regulatory agencies and

among various congressional staffs of both parties, as well as inform decisionmaking in a variety of state and foreign governments. The demand for our work has not diminished.

Second, leaders in Asia, Europe, and elsewhere have shown increasing interest not only in our current work but also in how they can create, in their home countries, think tanks akin to RFF. They see US think tanks as one of America's strong assets. We Americans would be wise to remember that one of the pillars of America's "greatness" is its intellectual infrastructure—our universities, our think tanks, and the analytical shops in government, industry, and a host of nongovernmental organizations.

Finally, let me assert the obvious: in the United States and around the globe, we



face major environmental and resource challenges that are not amenable to simple solutions. Trustworthy analysis and serious public discourse will be needed. I have no doubt that RFF will continue to play its part in helping to address these challenges.

For RFF to have such impact, it must and will continue to adapt to the changing world. Our challenge is to keep our agenda focused on questions relevant to public and private decisionmakers who matter in the management of environmental and natural resources around the globe. We must continue to strengthen our engagement with stakeholders who bring knowledge and experience to the table. We

must continue to enhance our ability to effectively communicate our work.

RFF must remain true to its core commitment to high-quality, independent analysis. I am confident that the RFF staff, the board, and the new leadership will be dedicated to these values and continuous institutional improvement.

RFF's success also depends on the support of a wide variety of donors committed to making a difference on critical issues. I will certainly remain one of these supporters. ●

PHIL SHARP

President

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Who Pays to Plug Inactive Oil and Gas Wells?

JACQUELINE HO AND ALAN J. KRUPNICK

Plugging inactive oil and gas wells—those that have stopped producing for a certain period of time—and restoring well sites are the responsibility of the well operators. However, many inactive wells are left unplugged by the responsible operator. If left unplugged, an orphaned well can be an environmental liability: methane can leak into groundwater or the atmosphere, or brine—which may carry heavy metals or other pollutants—can leak into groundwater or surface water.

State and federal regulations require well operators to post bonds that are released only when they have properly decommissioned their wells. Despite this, several states have long lists of orphaned wells. As of January 2015, Kansas had reported more than 4,400, and as of July 2013, Louisiana had reported more than 2,800. In new research, we show that the costs of decommissioning these wells can be high—and these costs are often paid for by the states instead of the well operators.

Comparing the average costs of decommissioning orphaned wells in 12 states with the average required bond amount in each state, we found that average costs exceed average bond amounts in 10 of the 12 states (Figure 1).

When the cost of decommissioning a well exceeds the bond amount, the operator lacks

the incentive to clean up and might choose to leave the well in a state of temporary abandonment instead (pending a decision to restart the well or close it permanently). In the meantime, operators may become financially insolvent or records may be lost, leaving the state with the liability, which often exceeds the bond amount.

When we compared the costs of individual decommissioning projects to the average bond amount in six of the states where we obtained individual project data, we found that in every state except Oklahoma, the majority of the projects cost more than the average bond amount (Figure 2). Some projects can be especially expensive relative to the bond amount. For example, in Pennsylvania the most expensive 1 percent of projects cost at least \$66,516, which exceeds the bond amount for conventional wells (\$2,500) by more than \$64,000.

Aligning bond amounts with actual decommissioning costs is essential for ensuring that well operators pay to decommission their wells and, therefore, for protecting the public from environmental risks. A number of states have worked to increase their bonding requirements in recent years, including West Virginia, Maryland, Wyoming, Missouri, and Kentucky. In our new report, *Plugging the Gaps: Recommendations for Reforming Inactive Well Policy*, we offer recommendations for revising bond amounts, protecting states from expensive decommissioning costs, and managing inactive wells. ●

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ALAN J. KRUPNICK is a senior fellow and co-director of RFF's Center for Energy and Climate Economics.



Figure 1. Costs of Plugging and Restoring Orphaned Wells Compared with State Bonding Requirements

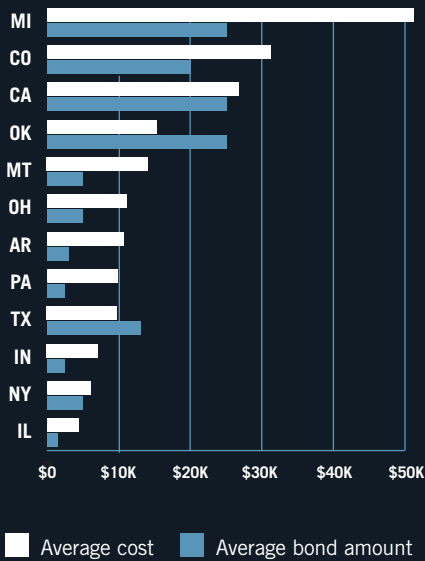
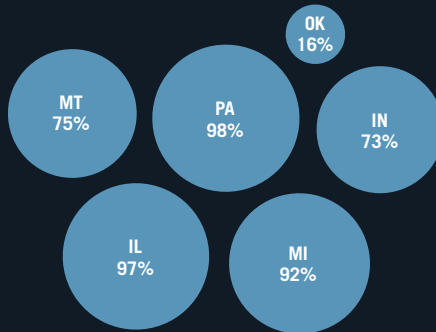


Figure 2. Percentage of Orphaned Well Decommissioning Projects with Project Costs That Exceeded Average Bond Amounts



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Highlights from Recent Events at RFF

Using the Clean Air Act to Regulate Greenhouse Gases

“The regulation of greenhouse gases under the Clean Air Act is not preordained by some divine power. It’s a policy choice that became necessary once what I would regard as a more administrable, efficient, and less-costly legislative program to control these gases failed in the Senate. EPA, quite understandably, said, ‘We never really wanted to do this. It’s not the best way to control greenhouse gases, but it’s what we’ve got, and we’re going to do it.’”

Bob Nordhaus, Partner, Van Ness Feldman LLP; October 15, 2015

Retrospective Analysis of Federal Regulations

“Very few new regulations over the last several years have included any discussion of retrospective analysis. Planning for future retrospective analysis can promote better rule design and focus data collection afterwards. So the Office of Management and Budget in the course of its executive order review of rules ought to be working with the agencies to develop a retrospective analysis plan for high-priority rules as part of the final rule.”

Arthur G. Fraas, Visiting Fellow, Resources for the Future; October 21, 2015

Complying with 2025 CAFE Standards

“If you don’t do a lot of hybridization, the only cars that comply are base-model compact and intermediate-sized vehicles. Once you get away from those vehicles, compliance becomes much more difficult.”

K. G. Duleep, President, H-D Systems; December 2, 2015

Trading Rules under EPA’s Clean Power Plan

“We believe in adding energy efficiency, we believe that [evaluation, measurement, and verification for energy efficiency] should be standardized, and we thought that what EPA was suggesting was in the right ballpark.”

Victor Niemeyer, Senior Technical Executive, Electric Power Research Institute; January 27, 2016

Partnering with the Federal Government on Drought Issues

“Because of all the different roles the federal government plays, it has a unique potential to bring actors to the table and get them to compromise on some tough basin management issues where there just isn’t enough water to go around without some of those compromises.”

Ellen Hanak, Director, Public Policy Institute of California Water Policy Center; February 3, 2016

UPCOMING EVENTS AT RFF

MAY 18: How Oil and Gas Development Impacts Local Governments and Communities

JUNE 1: Neuroscience: A New Direction for Valuing Environmental and Public Goods

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



Clockwise, from top: Bob Nordhaus at “US Climate Policy: How We Got Here and What It Means for the Future”; K. G. Duleep at “The Evolving US Vehicle Fleet: Responding to New Federal Regulations”; Ellen Hanak at “Improving the Federal Response to Western Drought”; Victor Niemeyer at “Expert Forum on EPA’s Clean Power Plan: Comments on the Federal Plan and Trading Rules”; and Arthur G. Fraas at “The Real Outcomes of Federal Environmental Regulations: Lessons from the Performance Data”.

Environmental Policy Issues in the “New Normal” Era of China

MUN HO

Worries about global economic growth frequently made headlines in 2015 and worsened early this year. There are bearish views even in the United States, which is enjoying a steady, if not typical, recovery from the Great Recession. Playing a big factor in this gloomier outlook are the growth prospects in China. The country’s GDP growth had averaged 10.6 percent per year during 2001–2011, with a massive stimulus sustaining high growth during the two years following the global financial crisis of 2007–2008. Since then, however, growth has decelerated sharply, down to 6.9 percent in 2015 according to China’s official GDP estimates. Since then, the term “New Normal” has spread from discussions in China to headlines across the world (see the box on page 9).

A slower-growing GDP could derail optimistic government plans for economic and environmental reform if the pressure to maintain growth results in a familiar pattern of energy-intensive investment in low-return infrastructure projects, such as buildings that sit empty and roads that go unused. Yet a different policy that promotes investments in energy efficiency, public transportation, pollution control equipment, and renewables would smooth the transition to the New Normal while reducing China’s severe air and water pollution.

Reform Ambitions Meet Reality

In 2013, newly installed leaders of the Communist Party announced their plans to reform the economy and government. The communique of the closely observed “Third Plenum” of the party, held in November 2013, speaks to balanced and equitable growth, environmental protection, and the key roles of markets in resource allocation.

The plan was to rebalance the economy away from the previous investment- and export-led growth and toward growth driven by consumption. Currently, China has one of the world’s lowest consumption-to-GDP ratios. Such a switch of production away from investment goods, such as steel and cement, would lead to a less energy-intensive economy. It would also mean less air pollution, addressing the great public concern about the nation’s extremely poor air quality—dubbed “airpocalypse” by the news media.

The unexpected slowdown since then has shifted emphasis back to maintaining growth. In speeches in November 2015, President Xi and Prime Minister Li announced that growth should be no less than 6.5 percent for the next five years, a target they seem to believe is necessary for social stability. Such an emphasis on growth might mean a delay, or a revision, of the reform plans. China has a decentralized government, where provincial officials wield substantial authority over local economic decisions, and it is easy to imagine many provinces returning to a familiar path of investment in infrastructure to reach such targets. Whether or not such a high invest-

MUN HO is a visiting fellow at RFF, a senior economist at Dale Jorgenson Associates, and a Harvard Kennedy School fellow.

Is China Headed for the “Middle-Income Trap”?

Growth deceleration has been a topic of intense discussion within China. As far back as June 2011, the *Economist* reported that “officials and experts debate endlessly whether the country is slowly heading towards a ‘middle-income trap,’” a situation where countries are unable to sustain high growth rates that had transformed them from poor to middle-income countries. As the World Bank noted in its report *China 2030*, “Of 101 middle-income economies in 1960, only 13 became high income by 2008.”

This way of thinking about growth is misleading, however; many countries that did not become rich in 50 years would go on to do so in 60 or 70 years.

The debate held around 2011 had many arguing then that China would be able to sustain 8 percent growth rates for two more decades. Such views are less common today, with the OECD projecting in its November 2015 *Economic Outlook* that China’s growth will slow further to 6.2 percent in 2017. But even if growth slowed to as little as 4 percent during 2020–2030, China would still escape the so-called trap—and energy consumption would continue to grow at about 2 percent per year without a big change of policy.

ment path would succeed in sustaining 6–7 percent growth, production of steel, cement, electricity, and other energy-intensive commodities would increase, resulting in higher levels of pollution and carbon emissions than envisioned in the earlier plans for a smooth rebalancing of the economy.

There are indications of this return to investment. In 2012–2014, the investment share of GDP exceeded 46 percent, even higher than the 40 percent that prevailed in the years before the global financial crisis. This higher investment has replaced the greatly diminished trade surplus and left the consumption share around 38 percent, which is similar to the share in 2006–2007. For comparison, the investment share in Korea peaked at 37 percent in 1991, while the US share was 20 percent during the dot-com boom.

Policy Choices in the Age of the “New Normal”

Two big initiatives are related to China’s focus on investment. The first is the “One Belt, One Road” initiative of President Xi. This confusingly translated strategic initiative

refers to the project to develop infrastructure—through a state-owned \$40 billion Silk Road Fund—along the land route to Central Asia (the “belt”) and the maritime route through the Straits of Malacca to Pakistan and on to Africa (the “road”). The second is the creation of the Asian Infrastructure Investment Bank, championed by China to facilitate financing of large infrastructure projects in Asia, arguing that existing institutions such as the World Bank are too cumbersome. The primary motivation behind these two initiatives may be political considerations to expand Chinese influence along the New Silk route and in Asia. The economic slowdown introduces an additional need to sustain demand for Chinese industrial output.

By themselves, these initiatives are not large relative to China’s GDP of \$10.4 trillion, but there could be large multiplier effects in a period of low global growth—especially in the countries receiving these infrastructure investments, but perhaps also within China. For example, Silk Road investments in Greece have turned the port of Piraeus into one of the fastest growing in the region. At a minimum, the Chinese

leadership believes these initiatives will serve as new flexible institutions to implement an investment-led strategy.

These international initiatives may be complemented by domestic investment initiatives. Whether such investment strategies will lead to greater energy and emission intensities depends on the nature of the investments. A common criticism of the recent policies, including those in the stimulus following the global financial crisis, is that the investments were made in low-return projects, as symbolized by empty buildings and little-used roads. A continuation of such poor project choices would contribute little to future GDP and to more energy use and pollution.

I believe there is an alternate response to the economic slowdown that would maintain a high level of investment and have a high social return: a policy that promotes investments in energy efficiency, public transportation, pollution control equipment, renewables, electricity infrastructure, and the like.

Currently, roads sit empty in some places, while elsewhere, such as in Beijing, too-few roads and a lack of public transportation spell ever-worse congestion. China's power system presents another place to prioritize investments. Integration of wind and solar energy into the power system has been very poor for various institutional and structural reasons but could be much better. Promoting exports of such environmental equipment and construction would contribute to maintaining employment and reducing global pollution.

Returns on such public investments do not show up on any enterprise's accounts, but they would have a social rate of return in the form of lower transportation and health costs that would be reflected in higher future productivity. The social return would also include a more flexible and reliable electricity grid that would help lower the costs of mitigating greenhouse gas emissions.

This would be a win-win-win strategy—it allows the government to follow a familiar path of economic development policy, it would maintain aggregate demand and employment, and it would promote energy conservation and pollution reduction in the future, even if the short-run impact is greater output of energy-intensive goods. As Nobel Laureate Joseph Stiglitz recently advised in a January *Project Syndicate* article, “Let bygones be bygones.” China should not have built so many steel mills, but given that it has, it is likely better to use that steel to build subways in China and bridges in Pakistan than to shut the mills down.

Over the longer term, whether growth slows to 6 percent or 2 percent, further government reform is essential to sustainable growth. The party communique of November 2013 outlines many good ideas, including a more balanced set of incentives and tools for local officials instead of a singular focus on growth, a better social security system that would encourage a more typical level of consumption, and a richer set of environmental policies that would reduce the use of fossil fuel-burning vehicles and emissions from industry. Developing specific policies for these general themes is the key to healthy development in the age of the New Normal. •

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Helping States Prepare for the Clean Power Plan

An Interview with Karen Palmer and Anthony Paul

RFF Research Director and Senior Fellow Karen Palmer and Center Fellow Anthony Paul were among a team of RFF experts invited to assist states working with the National Governors Association on how to develop their compliance plans for the US Environmental Protection Agency's (EPA's) Clean Power Plan, the first national carbon reduction standards for power plants in the United States. They recently sat down with *Resources* to discuss the process.

RESOURCES: Can you tell us a bit about your work with the National Governors Association?

KAREN PALMER: The National Governors Association (NGA) occasionally facilitates “policy academies”—engagements with leaders from a variety of states around a particular multi-state policy issue. In this case, the policy academy was focused on EPA's Clean Power Plan.

Under the Clean Power Plan, EPA sets emissions or emissions rate targets for each state, and the states have to come up with their own plans to meet the targets. NGA invited us to help the teams who are writing the plans think through that process and model policy options for compliance.

ANTHONY PAUL: State environmental agencies have experience regulating conventional pollutants, but regulating



carbon is different because there is no economic control technology. One can't merely buy a machine to scrub the exhaust. Instead, policies have to be in place that induce market transformation—generating less with more carbon-intensive generators and more with less carbon-intensive generators.

RESOURCES: Which states did you work with, and did they share similar concerns?

PAUL: Several states applied to be part of the policy academy, and four were selected by NGA: Michigan, Missouri, Pennsylvania, and Utah. This represents quite a diverse group. Utah, on one hand, is among the smallest power-generating states in the country. On the other hand, Pennsylvania is among the largest, second only to Texas. Pennsylvania is a huge gas-producing state; it has a lot of gas generators. Missouri, by contrast, has very few gas generators. Michigan has an aggressive renewable portfolio standard relative to the other states. But although the technology mixes are different among the states, the pathways to compliance are largely the same. So their concerns were similar.

One of the big decisions in complying with the Clean Power Plan is whether to adopt a rate-based target—defined by how much carbon dioxide is emitted per megawatt-hour—or a mass-based target

“State environmental agencies have experience regulating conventional pollutants, but regulating carbon is different because there is no economic control technology. Policies have to be in place that induce market transformation.”

measuring total tons of carbon dioxide emitted. Every state shared that challenge.

RESOURCES: Why does choosing a mass-based policy or a rate-based policy matter?

PAUL: According to our model and in looking at EPA’s methodology, compliance with mass-based targets may be easier than compliance with rate-based targets in many states.

Coming into this process, I think all four states had in mind that they wanted to pursue rate-based policies because they wanted the option to grow their emissions from electricity output over time. But very early on, the modeling showed that the mass-based goals were actually easier to hit. That really transformed their thinking.

The states’ environmental folks are used to regulating emissions using a mass-based target—for example, regulating tons of sulfur dioxide and nitrogen oxides emissions. Rate-based policies are more complicated.

PALMER: Trading across sources is harder under a rate-based policy than under a mass policy. It involves creating emissions rate credits (ERCs), which are the instrument that would be traded. These credits are generated whenever a megawatt-hour of qualified electricity is realized, including from covered emitting generators, new renewables and nuclear units, and verified energy efficiency savings. Covered emitting generators must hold ERCs in a quantity sufficient to meet their emissions rate goals. To receive ERCs, renewable generators and energy efficiency service providers submit an eligibility application that the state must certify. Then the credits are verified after the fact by a third-party evaluator and can be sold to emitters who need them for compliance.

However, if there is a mass-based policy, energy efficiency or new renewables would help keep demand for allowances down, but the complicated ERC creation and validation process would not be required.

The other important thing about a rate-based policy is that it makes it harder to expand carbon dioxide regulation beyond the electricity sector. For example, EPA could eventually choose to expand the rule to include industrial boilers. Regulating tons per megawatt-hour at refineries is nonsense—there are no megawatt-hours. But tons (measured under a mass-based approach) is a common metric that allows for the integration of sectors.

PAUL: Mass-based targets also provide a degree of freedom in allowance allocation that is lost under a rate-based approach. The basic idea with a rate-based approach is that the method of allowance allocation is built in: eligible generators earn allowances by making megawatt-hours. In a mass-based approach, allowances can be

allocated per megawatt-hour, but there are other options, including auctioning allowances or giving the allowance value to local electric distribution companies, to help offset any increase in retail electric costs.

RESOURCES: Allowance allocation is a complex but important design consideration, with consequences for efficiency and fairness. Did you find that this was a front-burner issue for states?

PALMER: The states certainly appreciated how critical the issue of allocation was, and its importance was amplified when the proposed federal plan—which came out at the same time as the final rule in August 2015 and serves as a model for the states—put allocation on the radar screen as a method for dealing with emissions leakage.

If you're using a mass-based approach and only regulating existing sources and you give allowances on the basis of historic activity, then you create an incentive to shift away from generators whose emissions are capped to those whose are not. But those generators are still going to emit, so you have a leakage issue. An updating output-based allowance allocation (dispensed per megawatt-hour) is a way to deal with that.

In our research, we also looked at differences in regulation across states, which is a possible outcome under the Clean Power Plan. Some states may use mass-based targets, while others use rate-based. This could create an incentive to move generation from mass-based to rate-based states, but, as we have shown in earlier work, those incentives could be muted through allocating allowances in the mass-based state on an updating basis.

PAUL: One of the things I didn't anticipate was that auctioning allowances is a

nonstarter when states cannot raise revenue without legislative approval. Economists often prefer an auction over other methods of allocation because auction revenues can be used to reduce the cost of compliance.

RESOURCES: You've often said that regional cooperation will be a critical component to the successful implementation of the Clean Power Plan. How did states feel about coordinating with their neighbors?

PAUL: In general, many states are having discussions about building coalitions. For example, the Center for the New Energy Economy that Governor Ritter runs out of Colorado has numerous western states talking together.

PALMER: EPA also has made it easy for states to trade allowances without formal coordination by introducing the concept of a trading-ready state plan. Any mass-based state could trade with any other mass-based state that uses the same registry for tracking allowances. I think the agency recognizes the importance of the choice in creating opportunities for affected sources to trade with those in other states. ●

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LEADERSHIP ON CLIMATE CHANGE:

A Conversation with Québec Premier Philippe Couillard

RFF welcomed Philippe Couillard, Premier of Québec, for a Policy Leadership Forum on February 19. In his remarks, Couillard discussed critical energy and environmental issues facing North America, highlighting state-level initiatives in addressing climate change. A subsequent discussion with RFF President Phil Sharp touched on such topics as regional renewable energy projects, sustainable management in the Arctic Circle, and the “Canadian Energy Narrative.” Below is an edited selection of Couillard’s remarks from the event.

On Emissions Reductions through Cap and Trade

“The cap-and-trade system guarantees the achievement of emissions reduction targets because there’s a word ‘cap’ in cap and trade, which obviously is lacking in other methods of carbon pricing. The system can reduce emissions at the best possible cost to emitters who now have options, a degree of flexibility, and a defined period of time to meet regulatory requirements.”

On Hydropower

“At a time when both fossil fuels and nuclear power raise serious concerns, few industrialized countries can count on such abundant, clean, and renewable sources. The northeastern United States, in our

view, must take advantage of this strategic partnership with Québec hydropower to meet its own renewable energy goals and achieve long-lasting reduction of greenhouse gas emissions.”

On Electric Transportation

“Québec already has enough electricity to power, in theory, one million electric vehicles without affecting domestic supply or exports. So it makes the choice of electric over gas an easier one. We were the first province to implement financial assistance programs for electric vehicle buyers, and Ontario followed suit in recent days. So there are already children in Québec who have never been in a gas-powered vehicle because their parents bought an electric car. To them, naturally, a car needs to be plugged in just like a fridge or a TV set.”

On Creating a Green Economy

“Climate is not a contradiction vis-à-vis economic growth, development, and job creation because it stimulates development of low-carbon technology. The creation of sustainable green jobs and the example of electrification of transport is probably the best to give a practical idea of what we mean when we say this. It promotes the pursuit of economic and environmental goals while preparing for the transition to a low-carbon economy.”



On Future Policy Priorities

“Finally, 10 years after adopting the 2006–2015 Québec Energy Strategy, we have decided to review and issue a new strategy for the 2016–2030 period that will be aligned with the GHG emissions reduction target of 37.5 percent by 2030. It will aim to improve energy efficiency, reduce the quantity of all products consumed, increase bioenergy more generally and clean energy production. Energy efficiency, energy substitution, and behavioral changes are the three pillars of the energy transition required to reach these targets.”

On COP21

“It was important for Québec to be in Paris for this moment. Québec helped gain formal recognition of the role and involvement of Federated States in the fight against climate change. It also successfully worked with the Canadian federal government to ensure that the Paris agreement sends a positive message concerning the use of market mechanisms.”

On Climate, Society, and Economics

“Far from being an obstacle to growth, the fight against climate change will shape the economy of the twenty-first century, just like coal did in the nineteenth century and oil in the twentieth century. Innova-

tive businesses and societies have always adapted, found solutions, and developed products and services. Today those businesses and societies whose vision is adapted to the environmental challenges will be the big winners. And we plan to be one of them.”

On Creating a Net Positive Environmental Impact

“Norway is a very important oil producer but nobody blames them for environmental impact. Why is that? It’s because they have such proactive policies—the electrification of transport is one example—and people see that, globally, the net result for this country’s impact on Earth is positive. There’s no reason why in Canada we shouldn’t have the same approach.”

On Carbon Pricing and Public Opinion

“One thing that I know in spite of all the rhetoric is that ... the majority of the public want their government to [take action on climate] and show them the results. And they are even ready to pay through carbon pricing because they know the long-term benefits, in terms of job creation and improvement of quality of life.” •

View the video from the event and read the full transcript at www.rff.org/CouillardPLF.



THE *Sage Grouse* LISTING DECISION

How Changing Expectations Could Affect Private Conservation

Rebecca Epanchin-Niell, Kimberly Rollins, and
Michael H. Taylor

The greater sage grouse is one of more than 350 wildlife species that critically depend on sagebrush habitats, which span vast areas of the western United States and provide important landscapes for livestock grazing, energy and mineral development, and recreation. Yet the sagebrush-steppe is among the nation's most imperiled ecosystems—threatened by development, invasive annual grasses, and altered wildfire regimes.

In September 2015, the US Fish and Wildlife Service (FWS) decided not to list the greater sage grouse (*Centrocercus urophasianus*) under the US Endangered Species Act (ESA). Leading up to this highly anticipated decision, stakeholders throughout the western United States had worked for more than a decade to place the bird on sustainable footing. The FWS touts its sage

grouse strategy as the largest land conservation effort in US history and contends that it has significantly reduced threats across 90 percent of the species' breeding habitat.

In official statements that accompanied the ESA listing decision, the FWS cited the success of ongoing conservation efforts by private property owners—who are largely ranchers—as one of the important factors in its decision. Conservation efforts on private lands were essential because 31 percent of total sage grouse habitat and 80 percent of habitat for raising young birds are on private property. Two pre-listing programs associated with the ESA played key roles in engaging private property owners in sage grouse conservation: Candidate Conservation Agreements with Assurances (CCAAs), and Working Lands for Wildlife—Sage Grouse Initiative (WLFW).

CCAAs and WLFW are both voluntary programs in which private property owners agree to implement a set of conservation practices. In return, the FWS provides regulatory predictability through assurances

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that the conservation practices will not be modified or added to in the event that the sage grouse is listed under the ESA. Unfortunately, FWS's decision not to list could reduce the effectiveness of these programs going forward, for the following reasons.

First, landowners may perceive a reduction in program benefits due to a reduced likelihood of future listing. The benefit to private property owners of participating in the CCAAs and/or WLFW programs depends, in part, on the potential costs associated with a decision to list the species under the ESA. If private property owners now believe that future listing of the sage grouse is less likely than prior to the September 2015 listing decision, the perceived benefits from CCAAs and WLFW participation would be reduced and future enrollment may decline. Private property owners can withdraw from these agreements with just 30 to 60 days notice.

Second, reduced uncertainty about the necessary conservation to avoid listing may induce greater free-riding. Prior to FWS's decision, there was uncertainty among private property owners about what level of enrollment in CCAAs and WLFW would be necessary to avoid the species being listed. The September decision removes some of this uncertainty by contending that existing conservation measures were sufficient to avoid listing. If any property owners believe that the achieved conservation level actually exceeded what was required, some could choose to exit the CCAAs and WLFW programs and free-ride on others' conservation actions.

Third, costs remain high despite the decision not to list the sage grouse. As part of the decision, federal and state agencies have been mandated by the FWS to manage the sage grouse "as though" it had been listed under the ESA. While it is almost

certainly the case that the restrictions would be more onerous and costly had the species been listed under the ESA, the incentives to participate in CCAA and/or WLFW programs depend in part on there being a wedge between the costs of complying with land use restrictions with and without ESA listing. This wedge is diminished by the decision to manage the sage grouse as though it had been listed. Thus, the incentives for private property owners to participate in CCAAs and WLFW are also reduced, as there are likely to be fewer additional costs associated with listing.

Fourth, costs of compliance post-listing could be similar to costs under pre-listing programs on private lands. The role of CCAAs and WLFW in the decision not to list the sage grouse under the ESA reflects their perceived effectiveness at achieving sage grouse conservation objectives on private land. As such, post-listing conservation programs under the ESA (for example, Safe Harbor Agreements) could resemble these pre-listing programs such that costs could be similar. This would reduce further the cost wedge between pre-listing conservation and post-listing ESA compliance.

One way to view the CCAA and WLFW programs is as repeated games between private property owners and the FWS, which could bring unintended and costly consequences. In the coming months and years, it will be informative to observe any exit by current participants as well as new enrollment in these two programs. Changes in enrollment would have implications not only for sage grouse conservation but also for how private conservation agreements are assessed in future listing decisions. Understanding the dynamic incentives of voluntary conservation would facilitate improved design and assessment of these critical tools in imperiled species conservation. ●



The Value of Milder Weather

Maureen L. Cropper

Many Americans travel to escape the weather—we head to the beach in February or visit Maine in the summer. The weather can even factor into our moving decisions. As a result, we can think about climate as an amenity for which people are willing to pay. Understanding the amenity value of climate (what people are willing to pay to experience warmer winters or avoid hotter summers) is an important component of the benefits of climate policies. Household location decisions—which balance earnings opportunities and housing costs against local amenities, including summer and winter temperatures, rainfall, snowfall, and humidity—can provide some insight into this issue.

In recent research with my colleague Paramita Sinha of RTI International, we reviewed residential location choices for US households in 2000 to estimate

how much households are willing to pay for changes in mean winter and summer temperatures under two climate scenarios. Both are taken from the Intergovernmental Panel on Climate Change's *Special Report on Emissions Scenarios*, which presents a set of emissions scenarios based on different demographic, economic, technological, and environmental developments.

Scenario 1 is the more climate friendly, projecting that the atmospheric concentration of carbon dioxide (CO₂) will reach 550 parts per million (ppm) in the year 2100. As a result, on average, summer temperatures will increase by 3.3°F in 2050, and winter temperatures will rise by 3.4°F.

The more dramatic Scenario 2 leads to an atmospheric CO₂ concentration of 850 ppm, resulting in a 3.6°F rise in summer temperatures and a rise of 2.1°F in winter temperatures, on average.

Our results indicate that households are willing to pay to avoid cold winter temperatures and hot summer temperatures; however, these values vary significantly by

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residential location. In general, we see the following:

» *A connection between willingness to pay and where the household lives.* Unsurprisingly, we find a strong positive correlation between a household's willingness to pay for warmer winter temperature and the average temperature of the household's city: households that are willing to pay the most for warmer winters live in Florida, whereas those that are willing to pay the least live in the Midwest.

» *A connection related to weather tolerance.* Preferences for summer temperature and winter temperature are, however, an inverse relationship—households that prefer milder winters prefer milder summers, while households that prefer colder winters don't seem to mind the heat as much either (they are less willing to pay to reduce summer temperatures). As a result, households in the Midwest, on average, are willing to pay less to increase winter and reduce summer temperatures than households in the Pacific and South Atlantic regions.

» *The importance of regional preferences.* Although there is considerable variation, these patterns point to the importance of understanding and correctly accounting for regional preferences. Under future warming scenarios, winter temperature is likely to increase the most at northern latitudes, specifically in the Midwest and Northeast. But these areas have lower-than-average willingness to pay for warmer winters. This means that using an average willingness to pay for warmer winters for the entire United States is likely to overstate the value of warmer winters under most climate scenarios.

At the same time, households' willingness to pay to avoid hotter summers is greatest in the areas that are expected to experience about average increases in summer tempera-

“The amenity value of climate could significantly increase estimates of climate damages, even for moderate temperature increases.”

ture: the South and parts of southern California. Thus, using average willingness to pay for cooler summers will understate the value of avoiding hotter summers.

Together, these results suggest that ignoring regional preferences could understate the value of avoiding climate change. Taking them into account, we find that, aggregated over the entire United States, households are willing to pay 1 percent of their income to avoid the more climate-friendly Scenario 1 and approximately 2.4 percent of their income to avoid the more dramatic climate changes seen in Scenario 2.

Estimates of market-based damages associated with climate change in the United States have typically been in the range of 1 percent of gross domestic product for an increase in mean temperature of 2°C (3.6°F). Because Scenario 2 would result in average increases of 3.6°F in summer temperature and 2.1°F in winter temperature, our results suggest that the amenity value of climate could significantly increase estimates of climate damages, even for moderate temperature increases. ●

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Responding to the

CLEAN POWER PLAN and the UTILITY OF THE FUTURE RECOMMENDATIONS FOR STATES

Using the same guiding principles to navigate two transformational forces in the power sector will lead to a lower-carbon electric grid with more options for electricity customers.

Joseph Kruger

Market trends and technological advances in the power sector, coupled with new carbon emissions regulations, are transforming the energy landscape, bringing about a lower-carbon electric grid with more options and new services for electricity customers. In response to market and technology changes, states, utilities, and energy companies are moving ahead with regulatory reforms, investments, and planning for what is sometimes called “the utility of the future.” Meanwhile, it is clear that some form of carbon regulation is inevitable—either through the Clean Power Plan (under the US Environmental Protection Agency’s Clean Air Act authority) or as a result of future legislation.

Some of the same principles that are guiding the creation of new market and regulatory structures in the power industry also can help shape the design of carbon reduction policies. Ultimately, states that embrace the utility of the future will be well positioned to comply with the Clean Power Plan at lower cost, and states and utilities that are planning for carbon regulation will benefit from exploring how emerging market and regulatory structures and new technologies can provide new choices and services for consumers.

The Changing Power Sector

Together with explicit policies and incentives to promote renewable energy at state and federal levels, several market trends are changing fuels, technologies, and energy services.

» Implementation of energy efficiency standards and policies has led to slower growth in demand for electricity.

» Lower costs and increased penetration of distributed energy resources, such as residential and commercial solar panels, energy storage, microgrids, and combined heat and power, are reducing market share for utilities in some regions, as third parties or electricity customers implement smaller-scale energy resources.

» The electric grid is changing from a system of centralized power plants where power flows in one direction through transmission and distribution lines to consumers to a more complex system where information and electricity flow back and forth from the grid to consumers, guided by “smart” technologies, powerful “big data” analytical tools, and device-to-device communications (sometimes known as “the Internet of things”).

This transformation is potentially at odds with the financial incentives built into traditional regulatory and market structures. Under the traditional paradigm, utilities earn a return, based on their capital investment in power plants or grid infrastructure, to cover their costs of serving customers and earn a rate of return for their shareholders. If customers or third parties provide assets for the grid, the utility and its shareholders lose the opportunity to earn a return on those assets. In addition, if customers decide to generate their own electricity (or contract with third parties for energy generation), the fixed costs of utilities will be spread among fewer and fewer customers, thereby driving a need to increase electricity rates to recover these costs. In theory, these higher rates could create a continuing cycle of further defections from the grid followed by additional rate increases.

Key Issues for the Utility of the Future

In response to changing market conditions and consumer demand for distributed

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energy resources, some states—including California, New York, and Minnesota—are exploring the types of changes needed to incorporate these resources into the grid. Although the details of state approaches will differ as they address new market developments, some fundamental issues are cross-cutting: Who should own and operate distributed energy resources? How should these new services be valued? And what types of regulatory structures will be necessary to align the financial incentives of utilities with evolving markets and technologies?

Who Should Own and Operate Distributed Energy Resources?

In the traditional market structure, utilities have a monopoly over electricity distribution and a duty to serve customers at just and reasonable rates. However, some analysts have expressed concerns about whether utilities, rather than third-party energy providers or electricity customers themselves, can provide the most innovative and lowest-cost approaches to deploying new technologies. Moreover, some observers argue that incumbent utilities have an incentive to use their regulated status to discriminate against rivals by favoring their own distributed energy affiliates. Other analysts contend that, with appropriate oversight by regulators, utilities can equitably provide an open platform that facilitates distributed energy provided by a variety of participants. New York's Public Service Commission has proposed this type of utility-run platform as part of its "Reforming the Energy Vision," or REV, initiative.

How Should New Technologies and Services Be Valued?

A critical component of evolving regulatory approaches is how to value the new electric system services provided by emerging

"In response to market and technology changes, states, utilities, and energy companies are moving ahead with regulatory reforms, investments, and planning for what is sometimes called 'the utility of the future.'"

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technologies so that they can be incorporated appropriately into utility planning and ratemaking. This debate has been particularly prominent for rooftop solar, where there has been controversy over the rate paid to customers who sell excess electricity back to their utilities under net energy metering programs. Critics of these programs have argued that while consumers with solar panels can receive the full retail rate for their excess electricity, they also should be responsible for sharing in the costs of maintaining the electric grid, either through paying a fixed charge or through receiving less than the retail rate. Otherwise, critics say, the costs of these programs are shifted to other ratepayers who are not participants in the solar programs.

However, there are benefits to the electric system provided by distributed energy that may not be determined in markets or reflected in the current utility regulatory structure. These benefits could include avoided energy costs, avoided capacity costs for generation, reduced costs for ancillary services, lower line losses on the transmission and distribution system, and fewer

investments needed in transmission and distribution facilities.

What Types of Regulatory Innovations Will Be Necessary?

If traditional cost-of-service regulation is no longer aligned with emerging utility market structures, what types of new approaches are necessary? Some analysts believe that performance-based ratemaking—an approach that ties utility profits to achievement of specific targets or benchmarks—will fill the void. In the past, regulators have experimented with performance-based ratemaking on a number of utility issues, including nuclear unit performance and energy efficiency programs. More recently, New York has proposed a series of incentive mechanisms that would be measured and monetized. These mechanisms address metrics such as peak reduction, energy efficiency, customer information access, affordability, and interconnection.

Principles for the Utility of the Future and the Clean Power Plan

Several groups of experts have put forward high-level principles that could guide the development of new market and regulatory constructs. For example, one group of analysts proposed in a recent *Public Utilities Fortnightly* article a conceptual framework they call “grid neutrality” (analogous to “net neutrality” for the Internet) that views the electric grid as a fair and open platform that can facilitate new and innovative technologies and services. With a similar goal of guiding future market and regulatory structures, the Rocky Mountain Institute e-Lab concluded that the “ideal” structure should ensure efficiency, resilience, and reliability; create a level playing field for all resources; foster innovation; provide transparent incentives where necessary to

promote technologies that result in social benefits; minimize complexity; enable transition from traditional business models to new structures; and support the harmonization of business models of regulated and nonregulated service providers. Some of these principles are directly applicable to thinking through how different designs for state implementation of the Clean Power Plan can accommodate emerging utility regulatory structures.

The Clean Power Plan sets statewide standards for coal and gas electric generating units, based on the generation mix in the state. The standards are based on three “building blocks”—essentially types of technologies or approaches that could reduce emissions: heat-rate improvement at coal plants, a shift to natural gas generation from coal generation, and increased generation from new renewable energy.

While the targets are based on the three building blocks, EPA has stressed that the approaches to the plan available to each state are diverse and include a wide range of options on both sides of the electric meter. For additional flexibility, EPA provides states with two categories for the standard: a rate-based standard, in pounds of carbon dioxide per megawatt hour, and a mass-based standard, denominated in annual tons of carbon dioxide emitted.

Each state must develop a plan for meeting the standard and may band together in trading markets with other states that have chosen the same type of target. The following recommendations could guide those efforts or other future carbon regulation and would complement broader regulatory changes.

Provide a Transparent Price Signal

A mass-based target with allowance trading, like the classic structure of the successful



Acid Rain Program, will set an explicit price on carbon dioxide and provide clear signals for utility planning, regardless of the new market or regulatory structures that evolve. This is preferable to a rate-based target with tradable credits for energy efficiency or renewable energy (known in the Clean Power Plan as emission rate credits), because the quantity of credits is unpredictable and must first be generated and verified. Past trading programs have shown that eliminating the need to approve or certify a trading commodity on a case-by-case basis reduces administrative and transaction costs and leads to more active markets.

Create a Level Playing Field

As market and regulatory structures evolve, it will be important to encourage fair competition among incumbent utilities and third-party providers of distributed energy resources, energy efficiency, and other energy services. One important aspect of the Clean Power Plan—allowance distribution—could tip the balance in favor of different technologies and market participants. Key parameters that could affect a level playing field include whether allowance value is allocated to electricity producers, electricity consumers, or the government; whether allowances are auctioned or distributed directly to different parties; and whether states create allowance incentives for specific technologies and programs. Finally, a critical

factor is whether allowances are distributed based on historic generation or will be updated periodically based on generation output, which will create an incentive to produce more electricity from a source to receive more allowances.

Foster Innovation

The convergence of the Clean Power Plan with new utility business models could be a significant driver of innovation as companies look for new sources of revenue that don't depend on selling more electricity. Mass-based targets will be able to adapt rapidly to innovative technologies or combinations of technologies. This is because neither will there be a need to create new verification protocols to calculate credits every time a new grid technology is deployed, nor will it be necessary to have those methods approved by regulatory agencies. In the utility of the future, combinations of hardware and software innovations will create infinite variations, and the emissions reductions of each would need to be verified on a case-by-case basis by an independent third party under a rate-based plan. It is unrealistic to assume that regulators will be able to keep up with emerging approaches, and it will be important to avoid incentives to use the most easily verified measures at the expense of less verifiable but more cost-effective or innovative measures.

“The ability of a mass-based target to seamlessly incorporate market trends will be critical as utilities incorporate new ‘grid edge’ technologies and market structures in the coming years.”

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Facilitate State and Regional Priorities

A variety of policies and approaches could complement a mass-based emissions target, including ramped-up energy efficiency and renewable energy programs. Moreover, under a mass-based target, states could use changes to utility regulatory structures—such as updated rate design and improved utility resource planning practices—to drive emissions reductions and lower the costs of compliance. Finally, a mass-based target—with its clear price signal, well-defined tradable commodity, interstate flexibility, and streamlined emissions accounting rules—will best accommodate the regional power planning processes that will be critical for the evolving industry structure.

Provide Flexibility for a Range of Market and Technology Scenarios

Past experience illustrates that a cap-and-trade system with mass-based emissions targets is a particularly good structure for accommodating unanticipated market and technological developments. For example, the onset of the Acid Rain Program in the 1990s coincided with the deregulation of the railroads, which facilitated the transpor-

tation of western, low-sulfur coal to power generators and was a contributing factor to a dramatic drop in sulfur dioxide emissions in 1995. Similarly, the Regional Greenhouse Gas Initiative benefited from unexpectedly low natural gas prices driven by technological innovations that led to the shale gas boom in the United States. This ability of a mass-based target to seamlessly incorporate market trends will be critical as utilities incorporate new “grid edge” technologies and market structures in the coming years.

Planning for the Future

Addressing the issues associated with the “utility of the future” will take enormous effort by regulators, utilities, third-party companies, electricity customers, and other stakeholders. New technologies and services have the potential to create significant benefits for electricity customers and the environment, but only if the regulatory and market structures can be developed to facilitate these benefits. Given the difficulty of predicting exactly what mix of technologies and institutions will develop in the coming years, a mass-based approach to carbon regulation that covers the entire electric generation sector is the most flexible and “future-ready” pathway. ●

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Join RFF in a unique opportunity to advance how our organization delivers its objective analysis to policymakers around the world. The **Sharp Policy Engagement Fund** will enable RFF experts to more actively share research findings, lead policy dialogues, and expand the critical activities that help RFF achieve its mission of improving environmental and natural resource policymaking worldwide.

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To learn more about how you can support the Sharp Fund, contact RFF Vice President for Development Lea Harvey: harvey@rff.org or 202.328.5016.



RESOURCES
FOR THE FUTURE

US ENERGY POLICY in an INTERDEPENDENT WORLD

With climate change looming large, our diminished reliance on foreign oil does not mean we are free from concern about energy security.

Phil Sharp



On January 20, 2016, Secretary of Energy Ernest Moniz awarded RFF President Phil Sharp the 2015 James R. Schlesinger Medal for Energy Security. In Secretary Moniz's introductory remarks detailing Sharp's more than 40-year record of commitment and contributions to vital energy security policies—including his 20 years as a US congressman from Indiana—he concluded that Sharp “provided much of the foundation of our continuing efforts in energy and energy security policies.”

He applauded Sharp's data-driven approach to energy policy. “He was about substance,” Moniz said of Sharp's time in Congress. “He was about reaching across the aisle. He was about solving problems. He retired from Congress in 1994, but to the country's benefit, he remained deeply engaged in energy issues.”

In his acceptance speech, Sharp touched on various themes surrounding global energy security, punctuated by his signature wit. The following article is based on those themes.

Today we are in the midst of a drive to not just change but transform our energy systems in order to protect us from risks associated with climate change. In the 1970s, when James Schlesinger was a towering figure in energy and security matters, we similarly had a decade-long drive to transform our energy systems to protect us from risks associated with dependence on oil from the Middle East. The dramatic rise in oil prices accompanying the Arab Oil Embargo of 1973 raised economic and security alarms in the United States. President Nixon responded with policy recommendations labeled

“Project Independence,” and “independence” has been the watchword ever since in American politics.

Throughout the 1970s, Americans—especially in Washington—engaged in furious debates about how to cut oil dependence. In reality, various factions stressed differing goals: national security, economic growth, environmental protection, or consumer price protection. Out of those debates and through hard political bargaining, major energy laws were adopted, some of which are still on the books.

Despite these strong efforts to transform our energy markets, reliance on foreign oil only grew—although slower than would have happened without policy intervention—until the last few years brought breakthroughs in domestic oil and gas production (think fracking), the hiking of automobile fuel economy standards, and the adoption of substitute fuels.

In short, the drive to transform energy markets in the 1970s did not achieve the primary goal of independence, but decades later, America has benefited from the public and private investments that were made in technology, energy efficiency, and alternative fuels. The recent turnaround in the oil import situation is clearly positive for the American economy and for our national security, enhancing our leverage in the global politics of energy. In the last decade we witnessed several rounds of congressional action that helped bring about this change.

But the lessening of our dependence does not mean we are free from concern about the global market for oil that underlies so much of the global economy. A major crisis in the oil market would have clear costs for our economy and possibly for our security. Indeed, we live in an energy interdependent world.

PHIL SHARP is the president of RFF and a former member of the US House of Representatives, where he served 10 terms as a congressman from Indiana.

“There are many ways
our energy future will
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Interdependence beyond Oil

There are many ways our energy future will be affected by what happens elsewhere in the world. Such interdependence brings potential benefits as well as risks.

Policies and markets in Germany, Spain, and China, for example, have undoubtedly cut the costs of rooftop solar and contributed—along with state and federal US policies—to its spread in America. Foreign markets and foreign government policies are increasingly likely to play significant roles in the adoption of various technologies, from wind and solar to new designs of nuclear power plants.

The Digital Revolution, which has been transforming our lives and the economy, is significantly changing the ways we produce, deliver, and use energy. Digitalization has brought us incredible benefits as well as new vulnerabilities, especially for our electric sector. Cyber attacks can come from foreign governments, terrorists, or even tech-savvy teenagers who, on a lark, might bring down portions of our smart grid.

A recent post on the *Washington Post's Wonkblog* suggested we may be overly alarmist about cybersecurity, indicating that, to date, cute American squirrels are a greater threat to our electric grid than foreign hackers.

Yet I think most professionals in the field would argue that considerable vigilance and investment will be needed to protect against attacks and improve our ability to restore power should there be a hit. And greater coordination with foreign governments must be part of a protective strategy.

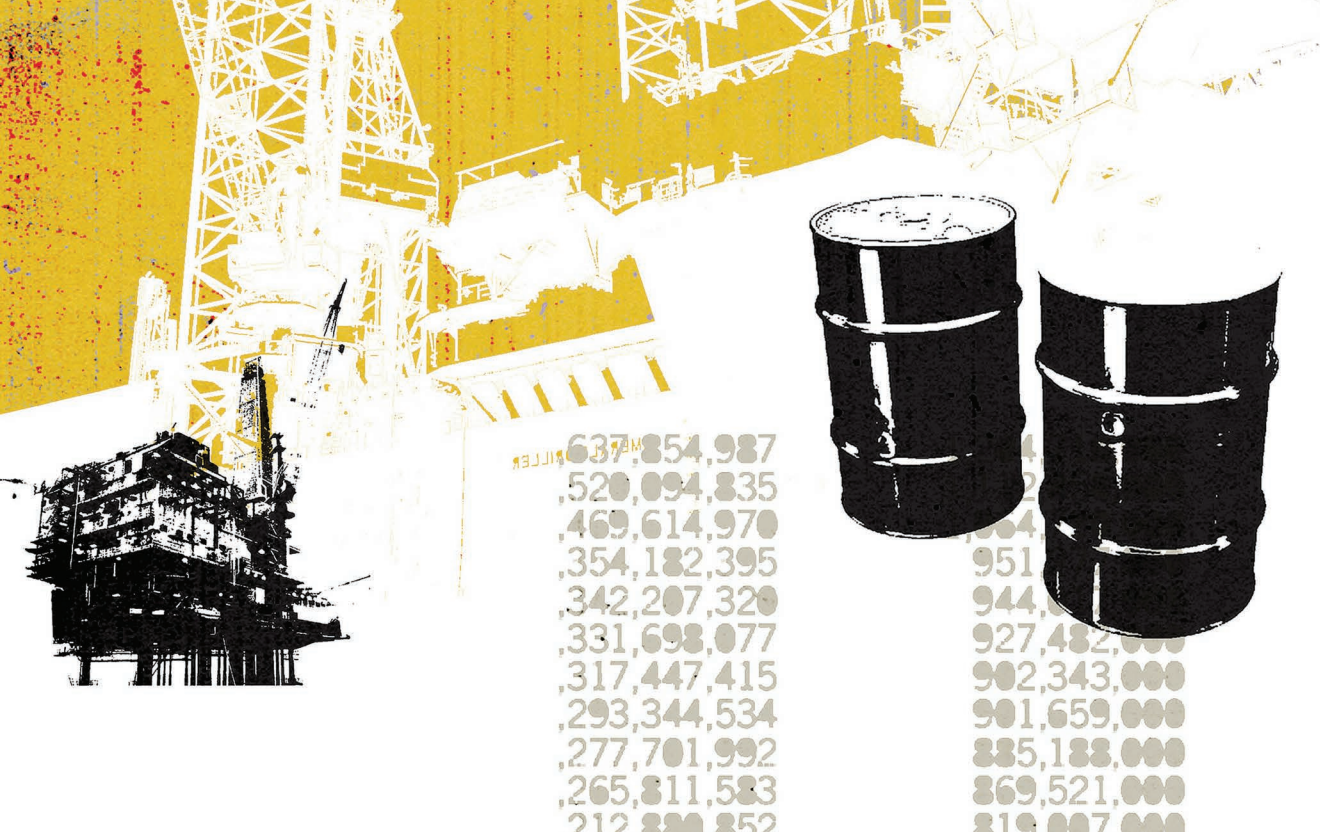
With respect to nuclear power, we have a critical common interest with other nations to keep the worldwide collection of nuclear plants operating safely and to keep nuclear materials secure from would-be weapons makers.

Secretary of Energy Moniz, supported by considerable talent in the department's national laboratories, deserves our gratitude for his work, along with the president and secretary of state, in completing the agreement with Iran, which will require continuing vigilance to prevent that nation from developing a bomb.

The safety of workers and people living near nuclear plants must always be the highest priority for governments and plant operators. There is also a mutually shared safety interest, since a serious accident anywhere is likely to have reverberations everywhere—as was the case following the horrific events at Fukushima.

New plants are being built around the world—many in the emerging economies where there has been little, if any, industry or regulatory experience with nuclear energy. Fortunately, our industry, our government, and our safety regulators have actively engaged with other nations to provide technology and experience.

It should also be recognized that most of the comprehensive studies on how to transform global energy systems to dramatically cut future greenhouse gas emissions include a nuclear component. They tend to recommend expansion of nuclear capacity or, at least, the continued operation of



current plants until we are certain that other pathways, such as efficiency and renewables, can have the impact necessary to achieve internationally agreed upon goals.

The Power of Price

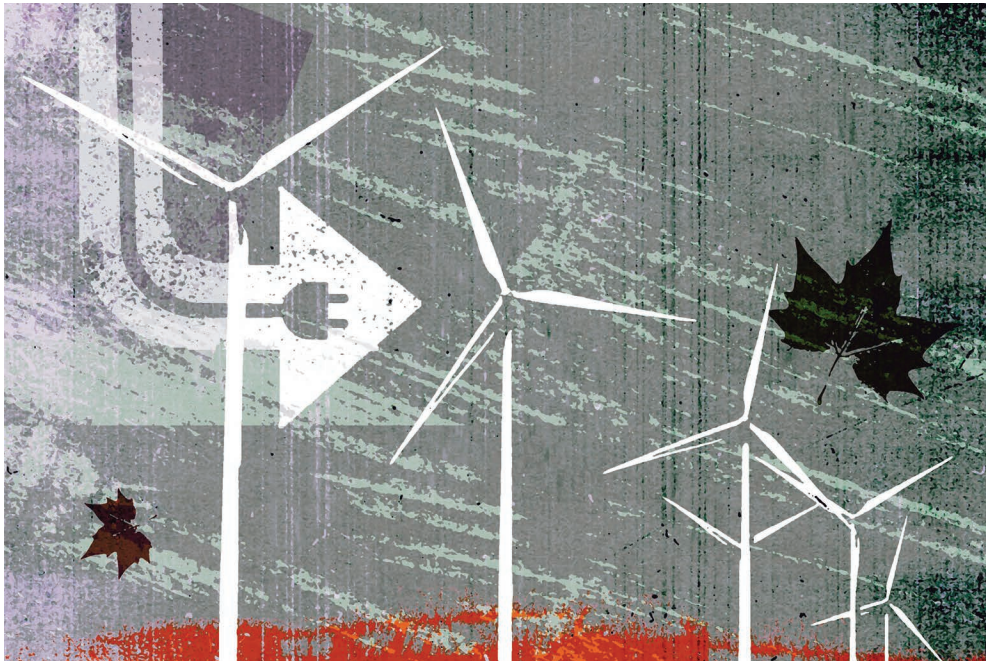
Over the last 40 years, a plethora of government policies at the federal and state levels have unquestionably had an impact on our energy markets, for better or worse. Too often in the public debate there is little appreciation for the significant role played by price swings in reshaping markets.

Significant price swings change the behavior of investors, business managers, consumers, and innovators. Major price increases stimulate greater end-use efficiency and greater investment in new technologies and substitute fuels. They have also triggered the adoption of policies—state and federal—pushing for innovation, gains in efficiency, and alternative fuels. In short, major price increases supercharge our markets and our politics. They are a blowtorch on the rear end of Congress. Indeed,

nearly all major energy bills followed on the heels of major price rises.

Likewise, when prices fall—as has happened recently with oil—consumers, investors, innovators, and political leaders tend to lose interest in such market changes.

In addressing greenhouse gas emissions, it is important to recognize the critical role of government policies to compensate for the current reduction in the market price stimulus. Moreover, as we look to the decades ahead, it is likewise important to look to carbon pricing policies to achieve major emissions reductions. In 2009, as we know, the House of Representatives adopted an admittedly complex pricing regime for carbon dioxide in preference to regulation under the Clean Air Act, although the Senate was unable to reach agreement on the issue. As a consequence of *Massachusetts v. EPA*, the failure of Congress to legislate, and the proactive leadership of President Obama, we have embarked on a near-term drive to regulate power plant emissions.



Interdependence and Climate Change

Our interdependence with other nations is nowhere more pronounced than in dealing with climate change. Greenhouse gases are emitted everywhere and the consequences of climate change are likely to be felt everywhere. Moreover, we are dealing with the two greatest “commons” problems: oceans and atmosphere. While the United States historically may have been the biggest emitter, we have now been surpassed by China in terms of annual emissions, and many other nations are significant emitters. Action by all such emitters is critical for success, and most nations are unlikely to take strong action unless others are doing likewise.

In part, the importance of the Paris agreement was to eliminate the excuse for inaction out of fear of inaction by others. That agreement has now established a framework for action by nearly all countries. To make it truly effective, strong leadership from major nations will be required—the kind of leadership shown by President Obama and

President Xi in their bilateral agreement that clearly advanced the making of the Paris agreement, demonstrating that no major nation would have to go it alone.

The American Climate Debate

At the moment, the American public debate is highly contentious, and the US Congress suffers from climate constipation. A few members of Congress are still looking to the Book of Genesis for scientific authority, but most members acknowledge the modern scientific consensus, and many have been working to get policy action.

Unlike most Americans today, I have high regard for many in Congress who work under very challenging circumstances. But let's face it: Capitol Hill is not Garrison Keillor's Lake Wobegon, where all the children are above average.

It is time to get past the denier debate and focus on cost-effective options for cutting emissions. I have every confidence we will see a change in Congress.

Despite the contentious debate, federal and state policies are still in place that redirect our energy future and, coupled with the recent substitution of gas for coal in the electricity sector, are making real progress in cutting emissions.

In the decades ahead, we face major intellectual and political work to deal with the many ramifications of climate change, especially if one assumes (as I do) that, worldwide, people want economic progress as well as environmental protection.

The Intellectual Challenge

Given the current presidential campaign, let me reaffirm what should be obvious. A main pillar of America's greatness is its intellectual infrastructure—by which I mean our universities; the analytical shops in government, industry, and environmental NGOs; and think tanks such as RFF. We must capitalize on these resources to meet the climate challenge.

However smart we try to be, our ability to foretell the future is limited. Indeed, many experts in government, industry, and academia have been wrong about oil and gas prices, technology developments, and the policies partisans in Congress would support.

While decades of scientific investment have given us incredible knowledge about climate issues and major analysis has been done on the policy front, uncertainties will remain for policymakers to confront—especially given the expectation that we will be dealing with these issues for decades.

America's Climate Choices, a study sponsored by the National Academy of Sciences, recommends an approach to taking action in the face of uncertainty: “iterative risk analysis.” Briefly stated, we do our best to assess the risks as we now understand them; we take action to mitigate those

“It is time to get past the denier debate and focus on cost-effective options for cutting emissions.”

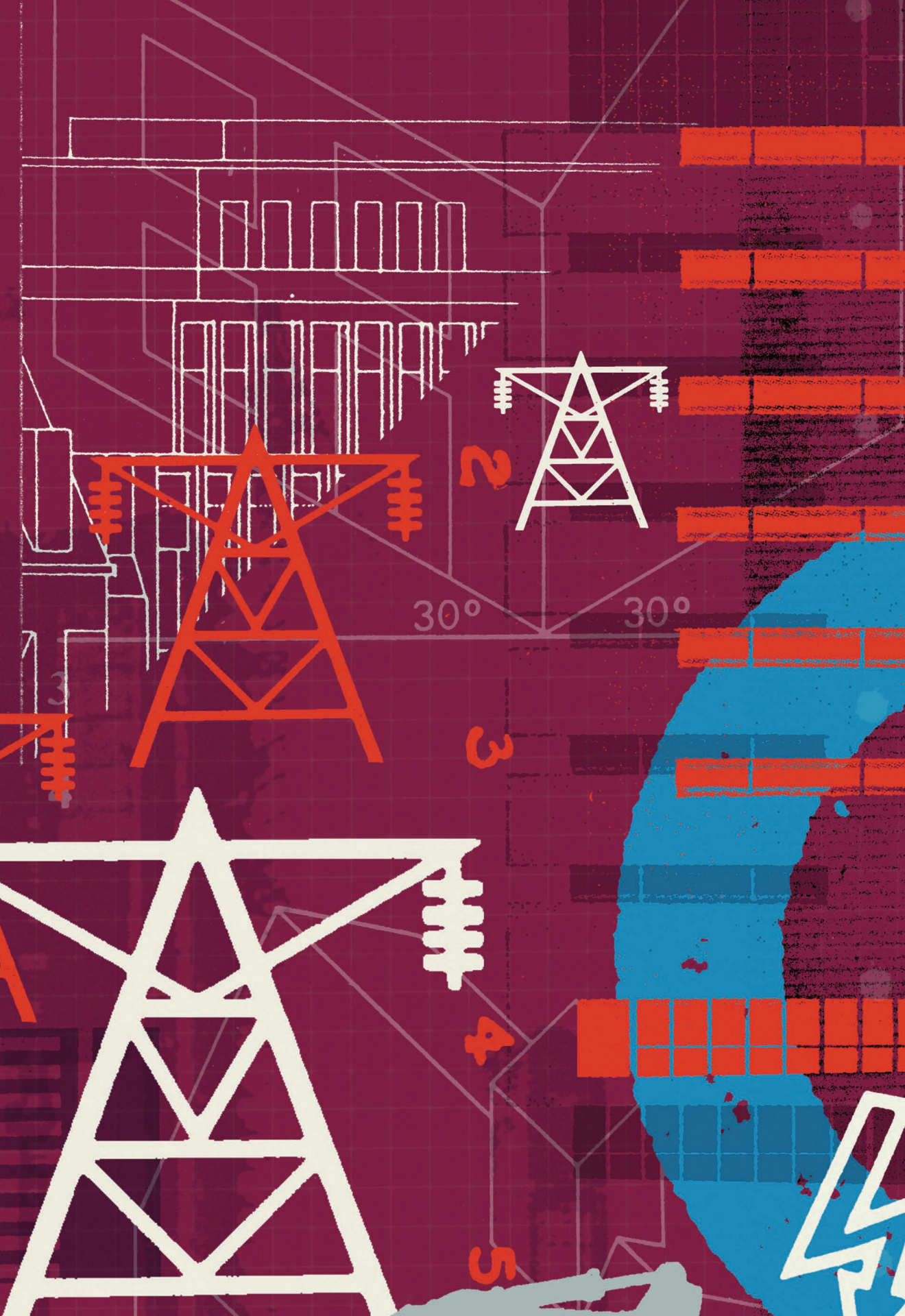
risks; and periodically (say, every 5 years) we reassess the risks based on what we have learned from the developing science and an evaluation of the effectiveness of related policies. Then we redirect policies in accord with our new understandings. While it is important to try to project ahead 30 to 50 years, it is highly unlikely that we can do so with a high degree of certainty. In some sense, this approach is part of the Paris agreement, which envisions regular updates in national commitments.

The Political Challenge

The path ahead in climate policymaking will undoubtedly see contentious debate and hard political bargaining. Such debate and such bargaining are offensive to many Americans, whether they work in America's intellectual infrastructure or in the farm fields of Indiana. But this process is the only hope for achieving sustainable policy.

Wisely, the founding fathers did not put the governing power in the hands of philosopher kings or a Soviet-style politburo. During the summer of 1787—a long, hot summer—they engaged in contentious debate, they engaged in hard bargaining, and they crafted our great Constitution. ●

The author wishes to express his gratitude to the many people who have been critical in his professional career: colleagues at RFF; former congressional staff and longtime friends Mike Kraft, Jack Riggs, and Shelley Fidler; energy policy mentors Charles Curtis and Robert Nordhaus; and former chairman of the Energy and Commerce Committee, John Dingell, an extraordinary legislator.



Harmonizing North American Electricity Policy *and* Planning

AN ACTION AGENDA

Key players in Canada, Mexico, and the United States recently came together to explore the wealth of opportunities to lower electricity costs, increase reliability, and tackle climate change more effectively through coordinated electricity policymaking and planning.

Alan J. Krupnick, Daniel Shawhan, and Kristin Hayes

Electricity production in Canada, Mexico, and the United States is evolving rapidly, providing the continent with an opportunity to reap economic and environmental benefits

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from tri-national coordination of both policy and system planning. To inform these efforts, RFF partnered with the US Department of Energy (DOE), Canada's International Institute for Sustainable Development, and Instituto Tecnológico Autónomo de México to host two workshops that convened key players from federal, provincial, and state governments; academic institutions; nongovernmental organizations; and the private sector. The result is an action agenda that highlights the diversity of opportunities for greater energy harmonization—from streamlining

“We use the word harmonization in the context of North American energy to cover a broad spectrum of activities, ranging from sharing information to considering impacts on neighboring countries to fully integrating energy policies.”

approval processes for new cross-border transmission projects to developing a North American Intended Nationally Determined Contribution (INDC) for 2050 to guide efforts to address climate change.

We use the word harmonization in the context of North American energy to cover a broad spectrum of activities, ranging from sharing information to considering impacts on neighboring countries to fully integrating energy policies, as one would in a customs union or common market.

Many examples of harmonization already exist in North America. For instance, in 2014 the three countries signed a memorandum of understanding on the sharing of energy-related data and definition of terms. The linked greenhouse gas cap-and-trade programs of California and Québec—soon to be joined by Ontario and Manitoba—provide an example of broad policy integration. More complete policy harmonization is illustrated by Canadian automobile emissions and fuel economy policies, which mirror those of the United States in stringency over time.

Benefits of Harmonization

Why might countries choose to invest the time and energy required to share information, coordinate policymaking, or even fully harmonize policies? Harmonization is not automatically beneficial, but it can lead to favorable outcomes under certain conditions.

First, harmonization is beneficial if it facilitates a worthwhile activity, such as power generation or emissions reductions, occurring where it can be accomplished at the lowest cost. Linking emissions cap-and-trade programs, enabling the free flow of power, and equalizing the marginal tax rate on generation, for example, are harmonization actions that can result in this benefit.

Harmonization is also advantageous if it reduces transaction costs. If regulatory requirements are sufficiently similar on both sides of a border, for instance, companies can use just one set of procedures for complying with them, saving the expense of having to follow two different sets.

Finally, harmonization can be constructive if it takes the form of coordinated decisionmaking that makes additional options possible. Considering the integration of assets and markets on both sides of the border through coordinated decisionmaking enables market access and system efficiency gains. For example, deciding to meet a system's needs with a new transmission line instead of a new power plant is possible only with coordination.

Steps toward Harmonization

In its 2015 *Quadrennial Energy Review*, DOE highlights the benefits of North American integration, noting it “expands the size of energy markets, creates economies of scale, lowers capital costs, and reduces energy costs to consumers” as well as increases electricity reliability. Among



the report's recommendations is the establishment of "collaborative programs in each country for academic institutions and not-for-profits to develop legal, regulatory, and policy roadmaps for harmonizing regulations across borders."

This served as the impetus for the RFF workshops, during which key players from the three countries examined policies, regulations, and planning associated with the electricity sector and identified many opportunities for harmonization (see the box on page 38). The following four broad recommendations from the workshops may be particularly worthy of near-term

attention as stakeholders work to prioritize specific action items.

1. *Embark on foundational research efforts.*

A need exists for additional tools to better estimate the benefits and costs of North American energy policy harmonization actions and of potential new transmission and pipeline links. Building an inventory of cross-border research to understand what analysis has already occurred and building tools for better and more extensive analysis are both essential.

2. *Expand participation in already-existing organizations.* Considering the low cost of effort, looking for opportunities to expand

Opportunities for Harmonization

The two workshops yielded a large number of ideas that DOE, other government agencies in all three countries, research groups, academics, stakeholders, and others could consider to move toward harmonization of energy policy and planning affecting the electricity system. These action items are grouped around systems operation, planning, and environmental regulations.

Action Items for Systems Operation, Reliability, and Transmission Pricing

- » Coordinate operation between neighboring systems more closely, including those on opposite sides of an international border, to increase reliability and reduce the total cost of the electricity supply.
- » Where transmission prices include extra charges in addition to the difference in marginal cost of supply, explore whether those extra charges are more distortionary than the alternative means of collecting the necessary revenues, such as higher income taxes or sales taxes.
- » Examine the extent of taxes that apply specifically to imported or exported power, such as Ontario's electricity export tax, and whether they should be eliminated.

Action Items for Planning, Siting, and Approval Processes

- » Assess whether US permitting of proposed cross-border transmission infrastructure investments can be streamlined. Related to this, assess whether the border crossing point can be agreed upon in an international review process.
- » Improve and apply benefit–cost analysis methods and standards for potential new transmission lines and other investments that increase cross-border transmission capacity.
- » Examine whether disagreements over cost allocation may prevent beneficial future cross-border infrastructure from being built. If so, attempt to establish a process for determining cost allocation that will prevent such disagreements. Calculating compensation for those who are likely to be hurt by such infrastructure could further improve the effectiveness of such a process.

Action Items for Harmonizing Environmental Regulations

- » On cross-border policy for conventional air pollutants (sulfur dioxide, nitrogen oxides, and ozone), evaluate whether cross-border pollution issues among the three countries warrant expanded policy harmonization beyond what is already covered in the US–Canada Air Quality Agreement—and also understand how any such pollution is distributed among the three countries.
- » Implement clear criteria to define renewables consistently in all three countries, including for purposes of facilitating trade in renewable energy credits and/or allowing imports of renewable energy to satisfy domestic greenhouse gas reduction requirements.
- » Conduct research on the subsidies, incentives, and taxes that exist for renewables in the three countries, as well as how electricity market competition compares across the three countries. Evaluate whether the differences create distortionary outcomes in terms of renewable energy siting.
- » Study how to facilitate Mexico joining California and the Canadian provinces in their linked cap-and-trade programs, or another large emissions trading program.

tri-country participation in existing organizations seems to be a clear priority: no new institutions are needed for it, and the value of information imparted to new participants (particularly from Mexico) could be quite high. For example, Mexico's power grid entities could join or closely coordinate with the Western Electricity Coordinating Council—a nonprofit group that assures a reliable bulk electric system in 2 Canadian provinces, 14 western US states, and northern Baja California—to enable mutual improvements in power system operation, planning, and acceptance of new transmission ties.

3. *Work toward greater climate policy integration, potentially leading toward a North American INDC for 2050.* Underlying a number of recommendations resulting from the workshops is the idea of closer, continent-wide collaboration on climate policy. As part of this, participants recommended setting a goal of developing a North American INDC for 2050—a set of climate commitments to achieve under the United Nations Framework Convention on Climate Change—and working backward from that goal to lay out the necessary steps to achieve it.

These steps could range from development of government-to-government working groups, to information sharing and planning for a coordinated INDC, to real greenhouse gas policy integration. Indeed, climate policy is one area where the United States, Canada, and Mexico have already announced a number of intended collaborative steps, including expanded linking of cap-and-trade systems and closer collaboration on methane reduction policies.

4. *Implement closer coordination of electricity system operation and planning.* Closer cross-border coordination would provide cost reductions and reliability improve-

“Underlying a number of recommendations resulting from the workshops is the idea of closer, continent-wide collaboration on climate policy.”

ments. Some specific targets include wide-area planning, improved benefit-cost analysis, streamlined project approvals, and an agreed-upon method of calculating cost allocations. In addition, regulators could enable greater coordination by modifying incentives for utilities.

The idea of integrating North American energy is not new. However, the significant changes over the past decade in particular—seen in the development of Canadian oil sands, the shale gas revolution in the United States, and major institutional energy reforms in Mexico—offer much to gain for all three countries, individually and together. Although moving on these recommendations is certainly no small undertaking, nor is addressing any—let alone all—of the specific action items, they hold real promise for continent-wide economic growth as well as opportunities to meet environmental and climate goals. •

FURTHER READING

Krupnick, Alan J., Daniel Shawhan, and Kristin Hayes. 2016. Harmonizing the Electricity Sectors across North America: Recommendations and Action Items from Two RFF/US Department of Energy Workshops. Discussion paper 16-07. Washington, DC: RFF.

US Department of Energy (DOE). 2015. *Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure*. Washington, DC: DOE.



DATA FROM DRONES

A New Way to See the
Natural World

The use of drones in environmental and resource economics offers a new means to gather data, the lifeblood of the field.

Molly K. Macauley and Timothy Brennan

Since the nineteenth century, when cameras were first attached to high-altitude balloons or harnessed to carrier pigeons, humankind has sought aerial vantage points for observing the planet. Thanks to declines in cost and improvements in control technology, today this capability is available to the public at large through civilian drones—not only for the fun of remote piloting but also for observing and monitoring our world. Businesses and governments, small and large, are taking advantage of this new technology as well.

As with many technologies, the early use of drones was by the military, but civilian use for hobbies, recreation, and professional interest is increasing rapidly. For example, a bird's-eye view of infrastructure aids the monitoring and inspection of pipelines, electricity transmission systems, and oil and gas rigs. Drone observation can facilitate real estate transactions by more accurately tracing property lines, and public property boundaries can be monitored as well—for example, in helping police wildlife reserves to discourage poaching. Drones can assess traffic congestion, accidents, and road closures in real time. They also can have critical uses in shortening response times and assisting in search and rescue missions following avalanches, earthquakes, and other natural disasters.

Most of these applications involve taking photos or videos. But in other cases, operators equip drones for special activities. Going outside the visible spectrum, drones can carry infrared sensors to assess the intensity and

project the spread of wildfires. Drones have been used to precisely apply small amounts of fertilizer or pesticides to hot spots in field crops and other agricultural areas and to deliver portable defibrillators to use in remote emergencies. Amazon is planning to use drones for the “last mile” of package delivery to residents’ doorsteps, and Google is considering the use of solar-powered drones to provide high-speed Internet service using millimeter-wave radio transmissions.

Drones also have the ability to collect physical material. For example, marine biologists have recently piloted drones through the blow (breath) of endangered whales to collect specimens of respiratory matter for testing viral and bacterial loads, the presence of environmental toxins, and hormone levels. These data are precisely time-stamped and geocoded to show the exact locations of the mammals.

These instances illustrate the advantages of drones: they can be easy and quick; precisely deployed, often in remote or dangerous locations; and come with the possibility of networking constellations of drones to provide specialized services. Combining a drone’s payloads also can be advantageous. For marine applications, the drone is designed to both take a photo or video and collect specimens, thus accurately recording the location, date, weather, and other conditions that may influence the biological measures.

The Promise of Drones for Research and Environmental Management

Because drones enable us to observe and measure so many natural resource and environmental phenomena, they are important tools in the arsenal of data collection. Drones add value to or even substitute for data collected in situ (such as

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“Because drones enable us to observe and measure so many natural resource and environmental phenomena, they are important tools in the arsenal of data collection.”

with stream gauges and in field samples), provide data that are nearly in real time rather than weeks or years old, and can often enable access to remote or extreme locations. In addition, they are low cost. According to some estimates, portable systems range from a few thousand dollars down to \$300 and often can be controlled from a smart phone.

Much as research economists may design field surveys, researchers seeking large data sets could design drone campaigns (using students and citizen scientists) to crowdsource data. On September 30, 2015, the White House announced a major science innovation initiative centered on both citizen science and crowdsourcing, citing their use in areas such as monitoring earthquakes and landslides, tracking bird migration, mapping marine debris, surveying beaches, and responding to and recovering from disasters. The National Oceanic and Atmospheric Administration (NOAA), US Geological Survey, and other agencies are already pioneering citizen science, including the development of guidelines for best practices and online resources, in part to demonstrate consistency and accuracy for information collected from drones.

Rules of the Road

Regulators, particularly the Federal Aviation Administration (FAA), have a broad role to play regarding how drones might affect commercial aircraft and people's lives and property on the ground. According to the FAA, today there are more drones registered than there are manned aircraft, with more than 342,000 listed drone owners (as of February 2016).

The FAA's current drone regulations can be divided into three categories, similar to those for automobiles: a requirement that owners must register drones, permission and qualifications to operate drones, and rules for their use (see the box on page 43). However, a notable difference between drones and cars is that a drone operator does not need to prove that he or she has liability insurance to cover damages caused by operating the drone.

In its February 2015 Notice of Proposed Rulemaking, the FAA outlined a set of rules specifically for drone operation. To gain the right to operate a drone, an owner would have to pass a test of knowledge of drone regulations, airport operations, weather effects, and other factors relating to drone performance. The rules also stipulate that small drones would not be operated over 18,000 feet or in airspace near airports without being subject to air traffic control. Operators would have to do a preflight check of the drone, local weather conditions, and the location of potentially harmed persons and property to ensure safe operation—far beyond what is required of car drivers.

Most notably, the proposed rules would require drones to remain visible to their operators at all times, where “visible” is defined as “unaided by any device other than corrective lenses.” No longer would operators be able to use cameras and GPS devices on board the drone itself to

Current Rules for Registering and Operating a Drone

It is not difficult to register a small unmanned aircraft system (sUAS). Any 13-year-old can do it with \$5—literally—by providing his or her name, address, email address, and aircraft manufacturer, model, and serial number. If the sUAS is intended to be used only as a model aircraft—that is, for hobby or recreational purposes within the operator's line of sight—only the name, address, and email are required. Registration lasts three years.

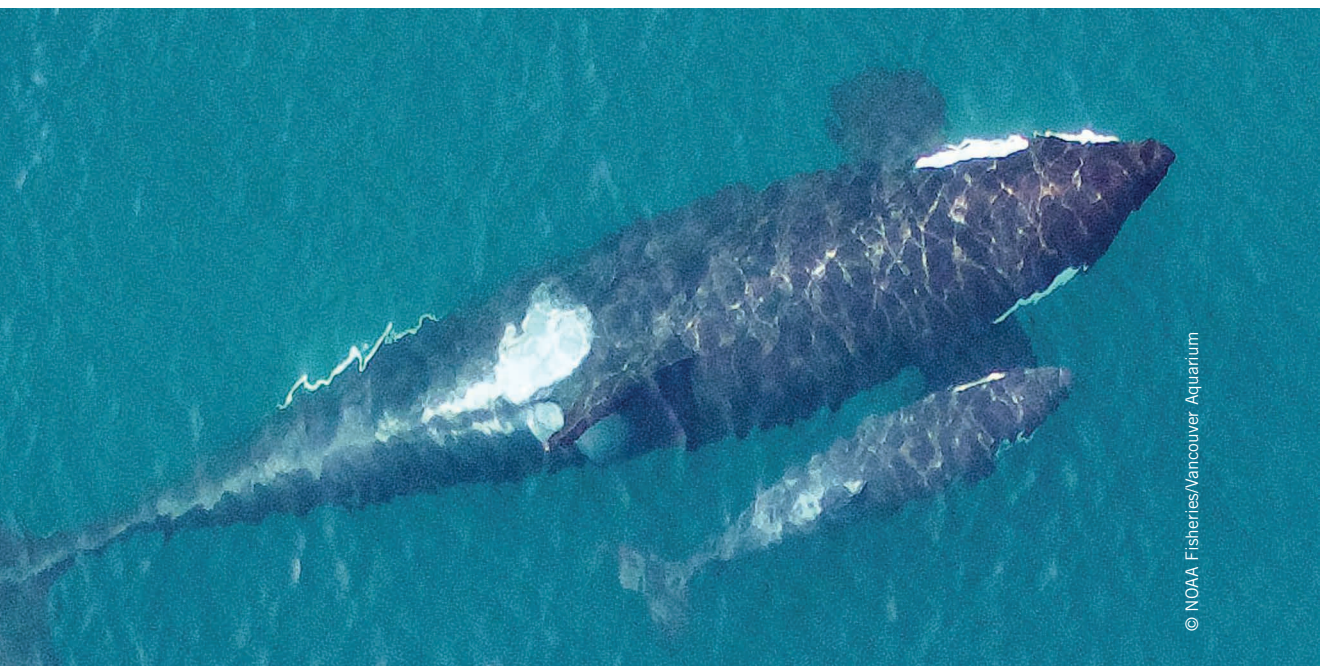
As with cars, registration does not imply that one has the right to operate a drone. Drone operators have to be at least 17 years of age, even though the age requirement to register a drone is just 13 years. Somewhat stronger than driving, grounds for denial include prior convictions on drug- or alcohol-related charges or refusal to submit to a blood alcohol test.

While a non-model sUAS cannot be operated without specific authorization from the FAA, model aircraft, until recently, could be operated nearly anywhere except within five miles of an airport without giving prior notice to air traffic control. In October 2014, the FAA added to that list, issuing a “Notice to Airmen” advising that, subject to criminal penalty, drones could not be flown within three miles of a stadium where a major league baseball game, professional or NCAA Division 1 football game, or NASCAR, Indy Car, or Champ Series race is being held—hardly an exhaustive list. In fact, a drone crashed into the stands during the 2015 US Open tennis tournament.





© Veronique LaCapra/Woods Hole Oceanographic Institution



© NOAA Fisheries/Vancouver Aquarium

In expeditions to study the health of marine mammals, NOAA scientists have recently used drones to monitor endangered groups of North Atlantic right whales off the coast of New England (top) and killer whales off the San Juan Islands (bottom). Research approach of whales using unmanned aerial vehicles was authorized by NMFS research permits and flights were authorized under a memorandum of understanding between NOAA and the FAA.

monitor its location and check for other aircraft, property that might be damaged, or persons that might be harmed. In addition, a person would be allowed to operate only one drone at a time, only in daylight, and could not operate the drone over anyone “not participating” in the drone’s operation.

These proposed rules could put a damper on many of the potentially beneficial uses for environmental management and research. For example, the requirements that an operator must fly only one drone at a time and keep it within direct eyesight would impede, if not effectively prohibit, the use of drones to observe and gather data from remote areas over land or water. (It is important to note that as of press time these rules have not been adopted. They could change following comments the FAA receives from the public.)

Other contexts may require additional permits, as in the case of marine applications. For recent expeditions, biologists received permits from NOAA’s National Marine Fisheries Service, with specific flight authorization from the FAA when over US waters, and from Fisheries and Oceans Canada with flight authorization from Transport Canada when in Canadian waters. The agencies provide additional guidelines for using drones to study protected marine species. Federal regulations restrict close approaches by air for marine mammals listed as threatened or endangered under the Endangered Species Act.

Future Possibilities

Drones hold great promise as a new means to acquire the data that are the basic bread and butter of Earth scientists and their colleagues in resource and environmental economics. Drones offer new ways to monitor activity as well—for example, whether regulations (often informed by

“Through citizen science, economists have an emerging opportunity to coordinate the wide deployment of drones, much like other on-the-ground survey methods but from a unique vantage point.”

.....

economics and policy study) to guard against poaching are working or need modification. And through citizen science, economists have an emerging opportunity to coordinate the wide deployment of drones, much like other on-the-ground survey methods but from a unique vantage point.

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. ●

Visit rff.org/resources to view a video of stunning Iguazu Falls captured via drone by RFF Fellow Marc Hafstead.

RFF Welcomes New Fellow, Announces Postdoctoral Researcher Program, and Remembers Henry Diamond

Awards and Appointments

RFF President **Phil Sharp** was honored with the James R. Schlesinger Medal for Energy Security, awarded at a ceremony at the Department of Energy in Washington on January 20, 2016. The medal honors distinguished contributions to advancing understanding of the threats, opportunities, and energy policy choices impacting the domestic and international energy security interests of the United States through analysis, policy, or practice.

RFF University Fellow **Simon Levin** of Princeton University is one of the latest recipients of the National Medal of Science. The National Medal of Science is one of the nation's highest honors for achievement and leadership and is awarded annually to individuals who have made outstanding contributions to science and engineering.

Sir Partha Dasgupta, Frank Ramsey Professor Emeritus of Economics at the University of Cambridge and an RFF university fellow, has been awarded the 43rd Tyler Prize for Environmental Achievement. Dasgupta was honored for his lifetime of work illuminating connections among poverty, sustainable development, and environmental health, and for developing economic theory and tools to measure the relationships between human and environmental well-being.

RFF Fellow **Kailin Kroetz** won the first 2014 Outstanding Doctoral Dissertation

Award from the Association of Environmental and Resource Economists for her research on the costs of restrictions in tradable permit programs.

RFF Fellow **Casey Wichman** received the 2015 Dr. and Mrs. Bill V. Lessley Dissertation Excellence Award at the University of Maryland for his doctoral work, "Information and Environmental Policy." This award is given annually to the student who wrote the best dissertation in agricultural and resource economics in the preceding year.

Phil Sharp and Board Member **John Deutch** have been appointed to the Secretary of Energy Advisory Board Task Force on the Future of Nuclear Power.

RFF Vice President for Research and Senior Fellow **Molly Macauley** has been approved as a member of the National Academies' Decadal Survey Steering Committee for Earth Science and Applications from Space, under the Academies' Space Studies Board.

RFF University Fellow **Jesse Ausubel** of The Rockefeller University was awarded an honorary fellowship by the American Geographical Society during its Fall Symposium, "Geography 2050: Exploring Our Future in an Urbanized World," held at Columbia University.

Allen Blackman, RFF senior fellow and RFF Environment for Development Program director, accepted invitations to become a member of AidData Research Consortium and serve on the advisory board

for the Northeastern Agricultural and Resource Economics Association's 2017 workshop, "Climate Change Impacts and Land Conservation."

RFF Welcomes New Fellow

RFF has named its newest fellow, **Daniel**



M. Sullivan.

Sullivan is a PhD student in Harvard University's economics department. He will join RFF this summer.

RFF Vice President for Research and Senior Fellow Molly Macauley said, "Daniel Sullivan's academic training includes environmental, labor, health, and urban economics. He also has terrific programming skills and familiarity with 'big data.' These are all skills necessary to successfully address emerging public policy challenges in several vital areas. We look forward to having him on our team."

Sullivan is a native of Gilbert, Arizona. He earned his BS in mathematics and economics in 2010 from Brigham Young University, where he graduated magna cum laude. His graduate work has taken place from 2011 to the present at Harvard.

RFF Postdoctoral Researcher Program

RFF welcomes postdoctoral researchers Christy Zhou, Andrew Royal, Nina Kelsey, and Yunguang Chen to this new program, supported by RFF and the Alfred P. Sloan Foundation.

Christy Zhou will join RFF to work with RFF Fellow Benjamin Leard and Senior Fellow Joshua Linn on transportation economics. She is completing a PhD at the University of Maryland, College Park.

Andrew Royal will work with RFF Research Director and Senior Fellow

Margaret Walls and Fellow Carolyn Kousky on repeated extreme events in coastal areas, using his expertise in behavioral economics. He is finishing a PhD at Claremont Graduate University.

Nina Kelsey is working with RFF Darius Gaskins Senior Fellow Dallas Burtraw remotely from California. She graduated from the University of California, Berkeley, with a PhD in political science and works at the University of California's Center for Information Technology Research in the Interest of Society, the Berkeley Roundtable on the International Economy, and Berkeley's Institute of Governmental Studies.

Yunguang (YG) Chen is working on modeling a carbon tax with RFF Fellow Marc Hafstead and Senior Fellow and Director of Academic Programs Roberton C. Williams III. He holds a PhD in economics from Oregon State University and previously was at the Center for the Blue Economy at Middlebury Institute of International Studies at Monterey.

In Memory of Henry Diamond

Henry Diamond, a champion for outdoor recreation and conservation movements, passed away on February 21, 2016.

Diamond was a longtime friend to RFF, serving for a time on RFF's Board of Directors and most recently as co-organizer of the bipartisan Outdoor Resources Review Group, which relied on RFF for the empirical research that informed its recommendations. The group's report, *Great Outdoors America*, laid the groundwork for President Obama's America's Great Outdoors Initiative. Diamond was the first commissioner of New York's Department of Environmental Conservation, an advisor to conservationist Laurance Rockefeller, and co-executive director of the White House Conference on Natural Beauty.

Highlights from Recent Journal Articles by RFF Researchers

The Housing Market Impacts of Shale Gas Development

Lucija Anna Muehlenbachs | *American Economic Review* | December 2015 | Vol. 105, No. 12 | 3633–3659

Using data from New York and Pennsylvania and an array of empirical techniques to control for confounding factors, Muehlenbachs estimates property value impacts from shale gas development that vary with geographic scale and water source. Results indicate large negative impacts on nearby groundwater-dependent homes, while piped water-dependent homes are positively impacted by proximity (although by a smaller amount), suggesting an impact of lease payments. At a broader geographic scale, new wellbores can increase property values, but these effects diminish over time. Undrilled permits, conversely, may cause property values to decrease.

Expert Judgement and Uncertainty Quantification for Climate Change

Michael Oppenheimer, Christopher M. Little, and Roger M. Cooke | *Nature Climate Change* | April 2016 | Vol. 6 | 445–451

Expert judgement is an unavoidable element of the process-based numerical models used for climate change projections and the statistical approaches used to characterize uncertainty across model ensembles. This article highlights the need for formalized approaches to unifying numerical modeling with expert judgement in order to facilitate characterization of uncertainty in a reproducible, consistent, and transparent fashion. As an example, the authors use probabilistic inversion, a well-established technique used in many other applications outside of climate change, to fuse two recent analyses of twenty-

first century Antarctic ice loss. They recommend indicators or signposts that characterize successful science-based uncertainty quantification.

Who Will Be Affected by a Congestion Pricing Scheme in Beijing?

Joshua Linn, Zhongmin Wang, and Lunyu Xie | *Transport Policy* | April 2016 | Vol. 47 | 34–40

An examination of the distributional consequences of a congestion pricing scheme currently under consideration in Beijing reveals that only a very small proportion of motorized trips would be subject to the full congestion charge. The directly affected individuals typically have higher household incomes and are wealthier than individuals who are not directly affected by the congestion pricing scheme. This finding reflects the fact that individuals who drive to work in Beijing are relatively wealthy. More important, the authors find that the Suits index for the congestion charge is 0.027, indicating that the congestion charge is slightly progressive.

Dynamics of Pollution Permits

Makoto Hasegawa and Stephen W. Salant | *Annual Review of Resource Economics* | November 2015 | Vol. 7 | 61–79

This article reviews the literature on bankable emissions permits that has developed over the last two decades. Most articles analyze either theoretical or simulation models. The theoretical literature considers the problem of minimizing the discounted sum of social costs and the possibility of decentralizing the solution through competitive permit markets. Simulations permit evaluation of alternative government policies under uncertainty. The authors conclude with directions for future research.

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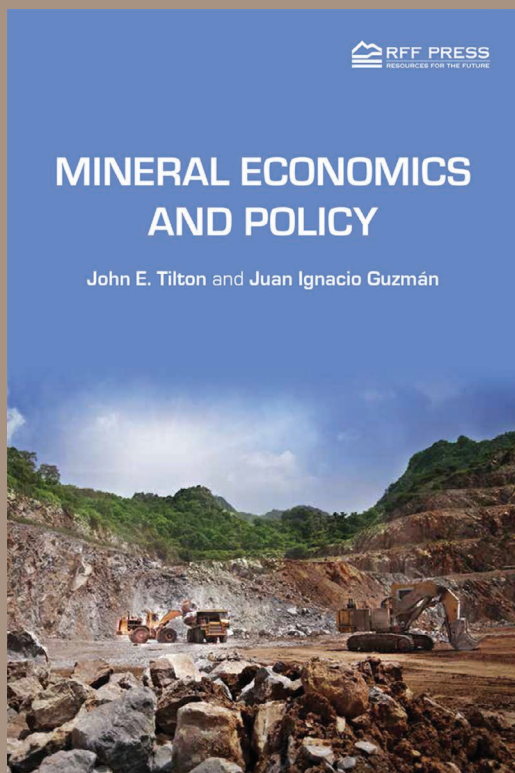


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