RENEWABLE RESOURCES JOURNAL

VOLUME 29-2015 NUMBER 2

CONTENTS

WWW.RNRF.ORG

About RNRF

Purposes

The Renewable Natural Resources Foundation (RNRF) is an I.R.C. §501(c)(3) nonprofit, public policy research organization, founded in 1972. It is a consortium of scientific, professional, educational, design and engineering organizations whose primary purpose is to advance science, the application of science, and public education in managing and conserving renewable natural resources. RNRF's member organizations recognize that sustaining the Earth's renewable resource base will require a collaborative approach to problem solving by their disciplines and other disciplines representing the biological, physical and social sciences. The foundation fosters interdisciplinary assessments of our renewable resources requirements and advances public policies informed by science.

Members

RNRF's members are membership-based nonprofit organizations with member-elected leaders. The foundation is governed by a board of directors comprised of a representative from each of its member organizations. Directors also may elect "public interest members" of the board. Individuals may become Associates.

MEMBER ORGANIZATIONS

American Geophysical Union

American Meteorological Society

American Society of Civil Engineers

American Society of Landscape Architects

American Water Resources Association

Geological Society of America

Society of Environmental Toxicology and Chemistry

Society of Wood Science and Technology

Programs

RNRF conducts national conferences, congressional forums, public-policy briefings and round tables, international outreach activities, and a national awards program.

Renewable Resources Journal

The quarterly journal, first published in 1982, features articles on public policy related to renewable natural resources. It also includes news from member organizations, general announcements, meeting notices, and international conservation news. The journal is provided as a program service to the governing bodies of RNRF member organizations, members of the U.S. Congress and staff of its natural resources- and science-oriented committees.

News and Announcements

Renewable Natural Resources Foundation

Round Table Meeting with the Library of Congress's Congressional Research Service

The RNRF Washington Round Table on Public Policy met on Feb. 23, 2015 with Congressional Research Service (CRS) staff members who specialize in natural resources policy. CRS representatives discussed the nature and scope of the agency's work.

CRS provides confidential, authoritative, objective and nonpartisan policy and legal analyses to members of Congress and congressional committees. Its five research divisions (American Law; Domestic Social Policy, Foreign Affairs; Defense and Trade; Government and Finance; and Resources, Science and Industry) are a valuable source of scientific and policy information on a wide range of issues of interest to the legislative branch. CRS approaches complex policy topics from interdisciplinary perspectives, analyzing current policies and the impacts of proposed policy alternatives. Research and analysis is made available to Congress via reports on major policy issues; tailored confidential memoranda, briefings, and consultations; seminars and workshops; expert congressional testimony; and responses to individual inquiries.

More information about CRS and its work is available at http://www.loc.gov/crsinfo/.

Standing (L-R): Pervaze Sheikh (Congressional Research Service), Roxanne Blackwell (American Society of Landscape Architects), Dick Engberg (RNRF Chairman, American Water Resources Association), Betsy Cody (Congressional Research Service), Jennee Kuang (RNRF), Melissa Goodwin (RNRF), Nicole Carter (Congressional Research Service), Amy Abel (Congressional Research Service), Erik Hankin (American Geophysical Union), Whitford Remer (American Society of Civil Engineers), Nancy Somerville (American Society of Landscape Architects). Sitting (L-R): Sarah Gerould (Society of Environmental Toxicology and Chemistry), Karen Paczkowski (Geological Society of America), Samuel Kim (Congressional Research Service), Tom Chase (American Society of Civil Engineers), Howard Rosen (Society of Wood Science and Technology), Peter Folger (Congressional Research Service). Robert Day (RNRF) present but not pictured.

Jennee Kuang

Kuang Appointed Research Associate

Jennee Kuang was appointed research associate for RNRF on December 1, 2014. For six months prior to the appointment, she had been working as an RNRF policy intern. Kuang received a B.S. in natural resources, with a concentration in resource policy and management, in May 2014 from Cornell University. While at Cornell, she interned with Cornell Cooperative Extension's Energy Corps, where she supported and developed local energy efficiency policies and initiatives. Prior to that, she worked as a research assistant in the Department of Natural Resources, researching climatic tipping points. She also served as president of Cornell's Chapter of The Wildlife Society and worked as a horseback riding instructor.

Kuang works with RNRF staff to develop and implement programs such as public policy conferences, congres-

sional forums, the Washington Round Table on Public Policy, and the annual professional recognition program. She also serves as assistant editor of the *Renewable Resources Journal.*

Round Table Meeting on the German Energiewende

The RNRF Washington Round Table on Public Policy met on April 27, 2015, with Dr. Georg Maue, First Secretary for Energy and Climate, at the German Embassy in Washington, D.C. He discussed Germany's transition to a sustainable, efficient, and secure energy supply (Energiewende). Maue highlighted the Energiewende's history and policies, challenges and opportunities, associated costs, and prevailing myths.

German Missions in the United States

The Energiewende benefits from very high levels of public support and a national commitment to sustainability. Motivating Germany's transition is a national understanding that the business-as-usual approach to energy production is unsustainable and causes significant economic and ecological damage.

Germany has been incorporating increased renewable power while simultaneously phasing out some traditional forms of power. For example, the country has been anti-nuclear since the early 1990s because of the risks associated with nuclear energy and the cost of nuclear waste disposal. Nuclear power previously accounted for 23% of the national electricity supply with 17 plants in operation. In 2011, Germany permanently shut down 8 of the 17 plants; plans are in place to phase out the remainder by 2022.

The Energiewende has three objectives: environmental soundness, security and reliability, and affordability and cost effectiveness. To achieve these objectives, German energy policies are designed to promote renewable energy sources, efficiency, and new infrastructure (the future grid).

Maue highlighted four challenges and opportunities posed by the energy transition.

1. *The saving potential of buildings*. Buildings emit one-third of Germany's emissions and make up 40% of its energy demands. Retrofits of existing buildings offer huge potential to achieve energy efficiency gains.
2. *The need to build new and smart infrastructure*. For the first time, there is a concerted federal effort to advance this work. Germany is working to build a smart grid and has several E-Energy pilot communities.
3. *Reducing Germany's greenhouse gas emissions*. In 2007, Germany pledged to reduce its emissions by 40% from 1990 levels by 2020. As of 2012, emissions have been reduced by 22%. The nation aspires to an 80-95% reduction by 2050.
4. *Base load power production is no longer required*. Instead, a flexible back-up power generation system is needed to supplement renewables on an as-needed basis.

One consequence of the Energiewende is that renewables are driving gas power plants, which provide energy storage capacity, out of the market. As a result, Germany has made use of the hydroelectric storage capacity of neighboring countries, including Norway and Austria. However, there is currently no European-wide energy policy. Cooperation between European states on energy is largely bilateral.

The most expensive phase of the energy transition is behind Germany, but it is still carrying the financial costs of that period. The Renewable Energy Act, for example, includes a feed-in tariff as a policy tool. It specifies that renewables have priority on the electricity grid and investors in renewables must receive sufficient compensation to provide a return on their investment, irrespective of electricity prices on the power exchange. Feed-in tariffs helped add 20 gigawatts of renewable energy

Remembering Al Grant

Former RNRF Chairman Albert A. Grant died on April 2, 2015, at his home in Potomac, Maryland. He was 88.

Grant was elected to the RNRF Board of Directors as a "public interest member" on November 8, 1994, and served until his death—for more than 20 years. He served as an at-large officer on the executive committee for eight years, as vice-chairman for two years, and as chairman of the board for four years—concluding his final term as chairman in 2006.

Grant chaired the RNRF Task Force on Educational Policy and Evolving Roles of Federal and State Natural Resources Agencies. Later he co-chaired the program committee of RNRF's Congress on Federal Agency Personnel Trends, Budget Stringencies, Challenges to Higher Education, and Evolving Roles of Natural Resources Agencies —held in association with the American Association for the Advancement of Science. He also chaired RNRF's International Activities Task Force.

Prior to his work with RNRF, Grant served as the elected president of the American Society of Civil Engineers, and served as chair of the American Association for Engineering Education's Sustainable Development Task Force. He was a leader.

Dr. Georg Maue

to the electricity mix between 2010 and 2012. Private investors own the majority of renewable energy, while utilities own only 12%. In Germany, about 2% of total household income is usually spent on electricity. Despite increased consumer electricity prices because of feed-in tariffs, percentage of income spent on electricity has remained constant as the share of renewable energy increased. Although energy in the United States is available at half the cost of German energy, the percentage of income spent is approximately the same because of greater usage rates in the U.S.

Finally, Maue addressed common myths surrounding the Energiewende. Germany has not seen an increase in electricity imports after closing several nuclear power plants; in fact, the country is producing a surplus of energy and exporting more electricity than ever. Although critics of the Energiewende point to increased outages with rising share of renewable energy, Germany's grid continues to be one of the most stable worldwide. Additionally, less nuclear power has not led to increased reliance on coal power. The general trend is towards less coal, with a small increase in 2012 and 2013 as coal power sought out new markets. Lastly, the energy transition has not had negative effects on economic growth, which has experienced an upward trend. With Germany's energy efficiency gains, GDP has been growing at a more rapid rate than energy consumption.

Germany's energy transition is not without its challenges, and difficulties will continue into the future. However, the country's ambitious, long-term energy and climate targets serve as an example of what gains can be achieved through concerted efforts.

For more information on the Energiewende, visit http://energytransition.de/.

Spring Meeting on the Energy-Water Nexus

The RNRF board of directors and guests met on May 6, 2015, in Washington, D.C. to discuss the energy-water nexus and its relationship to climate change. The energy-water nexus describes the inextricable linkage and mutual dependence of water and energy. Energy is required to supply, use and treat drinking water and wastewater. Water is needed for energy development and generation. While demand for energy and water is increasing, climate change will affect the availability and use of both water and energy.

The meeting's 20 participants discussed technological and political opportunities to manage to the energy-water nexus, as well as the implications of climate change and associated environmental stresses for the production and use of energy and water resources. The event featured presentations by three subject-matter experts representing the Department of Energy, Environmental Protection Agency and American Council for an Energy-Efficient Economy:

Continued on page 28

RENEWABLE RESOURCES JOURNAL

Renewable Resources Journal (ISSN 0738-6532) is published quarterly by the Renewable Natural Resources Foundation, 6010 Executive Blvd, 5th Floor, North Bethesda, MD 20852-3827, USA. Telephone: (301) 770-9101. Fax: (301) 770-9104. Email: info@rnrf.org. Website: http://www.rnrf.org © RNRF 2015.

Subscription rates are $30 for individuals ($35 for individuals outside the USA) and $49 per year for institutions ($55 for institutions outside the USA). Missing issues covered by paid subscription will be replaced without charge provided claim is made within six months after date of issue. Otherwise, payment at a single issue rate will be required. RNRF assumes no responsibility for statements and opinions expressed by contributors. Permission is granted to quote from the journal with the customary acknowledgement of source. Requests to photocopy articles for distribution to students and other academic users should be directed to: the Editor, *Renewable Resources Journal*, at the address above. Personal subscriptions are available to home addresses only and must be paid by personal check or credit card by phone or via PayPal at RNRF's website: www.rnrf.org. The mailing date of the most recent issue of the *Renewable Resources Journal* is posted at RNRF's website under the "Publications–Tables of Contents" link.

Editorial Policy: The editors seek general interest articles concerning public policy issues related to natural resources management. Recommended maximum length of manuscripts is 4,000 words. All manuscripts will be reviewed by the editors and, where appropriate, by experts in the subject matter. (A "Guide for Contributors" is posted at RNRF's website.) ***Editorial Staff:*** Robert D. Day, editor; Melissa M. Goodwin, associate editor; Jennee Kuang, assistant editor.

Sustainability in the Age of Big Data

The Wharton School, University of Pennsylvania

Introduction

Big data and climate change share one important characteristic: Both are changing the course of history. Carbon dioxide levels have not been this high in 800,000 years, and the amount of data being generated today is unprecedented.

The question at the recent Wharton conference on "Sustainability in the Age of Big Data" was how rapidly advancing information technologies can be brought together to forestall the worst ravages of global climate change. As Gary Survis, CMO of Big Data company Syncsort, IGEL senior fellow and conference moderator, noted, "It is rare that there is a confluence of two seismic events as transformative as climate change and big data. It presents amazing opportunities, as well as responsibilities."

Coming to terms with the scope of big data is a challenge, but the promise is enormous. Big data has the potential to revolutionize the two industries that generate the most carbon dioxide—energy and agriculture. Machine-to-machine communication can help reduce energy demands and increase the viability of renewable power sources. On farms, data from the molecular level may help give rise to a new green revolution, and sensors in satellites, farmland, trucks and grocery stores promise to reduce waste industry-wide.

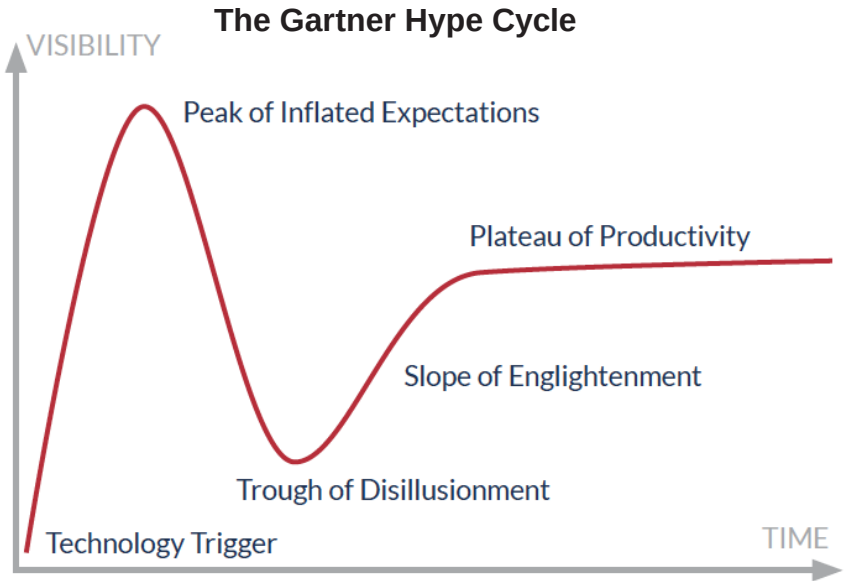
Important questions remain. Can big data be used to influence people's behavior without manipulating them? Can private enterprise capitalize on big data's possibilities without riding roughshod over the rights of those who generate the data? And can the high-tech innovations already underway in the developed world help solve the problems of those most in need?

How well we answer these questions will determine whether we can realize the historic potential of "Sustainability in the Age of Big Data."

What Big Data Means, and What It Can Mean for Sustainability

The first Industrial Revolution showed the world how much machines could accomplish. What GE calls the "Next Industrial Revolution" is now showing how much machines can accomplish when they communicate with each other. And just as steam—and later electricity—powered the first industrial revolution, Big Data is powering the second. Machine-to-machine communication (M2M) gave birth to the age of Big Data and advances in big data are expanding our sense of what the Internet of Things can accomplish in the coming years.

It's too soon to know whether or not the promise of Big Data is being overstated. Google Trends shows that the number of news references for "Big Data" has increased ten-fold since 2011. Comparing that with the Gartner



This article is an excerpt from Sustainability in the Age of Big Data, a September 2014 Special Report by the University of Pennsylvania's Wharton School of Business. It is republished with permission from Knowledge@Wharton (http://knowledge.wharton.upenn.edu), the online research and business analysis journal of the Wharton School. The full report, including sections on Big Data in the agricultural and energy sectors, can be accessed at: http://knowledge.wharton.upenn.edu/special-report/sustainability-age-big-data/.

KNOWLEDGE@WHARTON

Hype Cycle suggests that the concept may be nearing its "Peak of Inflated Expectations" and will soon be sliding into a "Trough of Disillusionment" (see accompanying graph). Still, if the Hype Cycle is an accurate forecast of the future, it seems reasonable to expect great things from Big Data once it reaches the "Plateau of Productivity."

The Four V's of Big Data

According to Wayne Balta, vice president of corporate environmental affairs and product safety at IBM, Big Data is defined by the four V's: volume, velocity, variety and veracity.

Volume is self-explanatory, although it doesn't do justice to the scale of Big Data. Nothing really does. Very big numbers are commonly used to suggest the enormous quantity of data now being generated (every day, we create 2.5 quintillion bytes of data), as are comparisons with previous accumulations (90% of the data in the world today has been created in the last two years), but our minds are simply not equipped to grasp such scale. That's why we need computers.

Velocity refers to the speed with which vast amounts of data can be ingested, integrated and analyzed for use "in real time." Real time means virtually instantaneously. To deliver driving directions in real time, the company Inrix, for instance, gathers data about detailed traffic speeds every 800 feet across four million miles of road in 37 countries; fuses this with journalistic reports of traffic incidents, congestion alerts, maps, traffic-camera video and more; analyzes all this data, and turns the analysis into actionable directions—all quickly enough for a highway driver to use while looking for the right exit to take.

As part of the presentation he gave at the recent conference on "Sustainability in the Age of Big Data," sponsored by Xerox and Wharton's Initiative for Global Environmental Leadership (IGEL), Balta said that 90% of Big Data is unstructured, which means that it lacks a common format. The data includes images ranging from infrared photos to high-definition videos; recordings of bird songs and human speech; the raw feed from sensors sitting on the Martian surface and floating far out at sea, and communications of all kinds: handwritten medical records, typeset books, ancient scrolls, social media posts and emails—all contribute to the vast variety of information that has to be "ingested" and merged with structured data before it becomes useful.

No matter how much structured and unstructured data is ingested, or how quickly it is analyzed, it's of little help if the decision makers using Big Data don't trust the input or the output. Today, one in three business leaders don't trust the information they presently use to make business decisions, and 27% of respondents in one survey said they were unsure how much of their data was accurate. IBM calculates that "poor data quality costs the U.S. economy around $3.1 trillion a year." Clearly, to be successful, Big Data analytics has to include a means of verifying all the varied data it uses.

One cause of concern in the Big Data community is cultural: uneasiness about sharing data. Privacy is one obvious obstacle, but so is distrust among competitors in the corporate world and even among business units within the same company. Even when the data is available, a dearth of scientists skilled in the field often prevents companies and governments from taking full advantage of all it has to offer. Paul Rogers, GE's chief development officer, told the IGEL conference that right now, "only about one-half of 1% of the world's data is being analyzed." The other 99.5% falls into the category of "dark data."

The Next Step in Big Data

Almost all computers today use the same essential approach to data crunching. Based on the work of mathematician and physicist John Van Neumann, they separate memory from processing, and work by executing pre-written, coded instructions. As computing power has grown, it sometimes seems that modern computers are doing something much more sophisticated than this. But the difference between most of today's computers and those at work 50 years ago is modern machines do a lot more number crunching a lot faster—but they still do it in essentially the same way computers have always worked.

The first attempts to move beyond standard Van Neumann architecture focused on Artificial Intelligence (AI), which envisioned machines that would think better and faster than human beings, eventually solving problems without any human intervention.

More recently, IBM has developed what it refers to as Cognitive Computing, which aims instead for a "natural interaction" between computers and people. Making use of a new "neurosynaptic chip" and a computing architecture that brings together memory, processing and two-way communication with people (using natural language and visualization techniques), IBM's cognitive computing system Watson made its debut in 2011.

Competing on the TV show *Jeopardy!*, Watson beat the game's most accomplished players without any access to data outside its own internal memory. To accomplish this feat, IBM data scientists spent years not only developing the ways Watson ingests, stores and processes huge amounts of varied data, but also feeding the system data from virtually every field of knowledge that *Jeopardy!* questions might focus on. On game day, Watson had to figure out what was being asked (not always an easy task on *Jeopardy!*); generate thousands of possible answers; assemble evidence to evaluate and establish a confidence level for each of these possibilities, and then analyze the current situation in the game to gauge whether or not to risk pressing

the buzzer to offer its best answer—all in about three seconds.

Watson won, and has since moved on to more serious pursuits. The system is now helping doctors at Memorial Sloan Kettering Cancer Center in New York diagnose patients and decide on the best treatment options. In the future, Watson's successors may help humans run cities, manage their investments, improve retail sales and accelerate advanced research. Thanks to a recent agreement with Apple, Watson may even someday replace Siri, the iPhone app that understands spoken language and tries to answer users' questions by accessing the web. Watson would presumably provide better answers without having to use the Internet and, in the process, would greatly expand its own knowledge base.

Optimizing Business, Environmental Performance

Big Data is also likely to help the world solve some of its most intractable environmental problems. Other articles in this report explore the ways in which Big Data is helping to meet the planet's growing demand for energy and food as the world population reaches near nine billion and climate change threatens drastic reductions in resources.

Another powerful use of Big Data is its ability to help assess environmental risks, both in real time and in the future. Charles Iceland, senior associate of the markets and enterprise program at The World Resources Institute (WRI), told IGEL conference attendees about Aqueduct, WRI's interactive water-risk mapping tool, which calculates overall water risk anywhere on the planet, based on a variety of risk factors related to the quantity of water, its quality, and changing regulatory and reputational issues in the region. Users can access the tool without charge online, choosing which factors they want to focus on and how they are to be weighted (based on the industry involved). They can zoom in to look at small areas or zoom out to take in whole continents.

Aqueduct can also show how water risks change over time, providing forecasts for 2025 and 2095, based on three distinct scenarios. Color-coded results are typically generated in a matter of seconds, enabling corporations concerned about water use to focus conservation efforts where they are most needed, and to site future operations where water is most available.

IBM's hyper-local weather forecasting system, Deep Thunder, is offering a handful of U.S. utility companies a different kind of risk assessment. Using Deep Thunder, these utilities can predict where highly localized weather events are most likely to cause outages, allowing the company to position crews where and when they are most needed to restore service. This ability reduces the time that customers are without power, decreases the company's costs and optimizes the use of the energy being produced.

Optimization of resources is a hallmark of Big Data's contribution to the triple bottom line. David Parker, vice president of Big Data for SAP, offered several examples at the IGEL conference. Pirelli, the Italian tire company, works with SAP's big-data management system, HANA, to optimize inventory using second-by-second data generated by sensors in its tires worldwide. The result: less waste, more profits and fewer tires heading to landfills.

Alliander, the large Dutch utility, uses HANA to keep the grid running at peak efficiency, increasing profits and reducing environmental impact. Jeroen Scheer, manager of task force transition at the company, says that it used to take 10 weeks for the company to optimize the grid, a task it completed once a year. "Now we can do it every month and it only takes three days," Scheer notes.

Even incremental improvements in efficiency can add up to huge savings. In his closing keynote address at the IGEL conference, Rogers spoke about the potential of Big Data to optimize performance throughout the business world. Just a 1% improvement in efficiency in five of today's major industries—aviation, health care, power, rail, and oil and gas—could save $276 billion over the next 15 years, said Rogers. That's a lot more profit for the companies involved and a lot less damage to the environment.

More Effective Regulation

Profit is a great motivator in the business world, but it is not always the most effective source of environmental progress. Regulation is sometimes needed to advance sustainability. Too often, though, regulation imposes burdens on businesses without benefiting the environment as intended. The problem, some say, is that legislators and regulators use an ineffective command and control approach to regulating business.

According to Cary Coglianese, a Penn law professor and director of the law school's Penn Program on Regulation, Big Data offers an alternative. By using Big Data techniques to integrate and disseminate previously protected information, governments can "unleash these regulatory shackles" and focus companies on results rather than rules. The firms are free to experiment and find the most efficient means of achieving the desired results, while the government can use improved sensor technology and real-time reporting of environmental quality data to monitor their progress.

Coglianese points to the 1990 Clean Air Act amendments as an early example of how data can be used to craft a more flexible approach to environmental regulation. Those amendments authorized what turned out to be a very effective emissions trading regime for dealing with acid rain, says Coglianese. "And that was made possible largely by the development of continuous-emissions monitoring technology that could be deployed at large utility facilities."

Public release of information can even help improve the data itself. Coglianese notes that when the Toxic Release Inventory (TRI) regulation was first established in 1984 after the Bhopal gas leak accident in India, the data released by companies was not very good. But once firms saw what happened when the media and others discovered and exposed flaws in their data, they quickly realized how important it was to get their facts straight. Today, TRI is generally considered one of the most effective environmental regulations ever enacted.

The next Industrial Revolution has begun and is already helping to advance sustainability worldwide. It is still early days, but if Big Data can power future progress as effectively as steam and electricity fueled the first Industrial Revolution, the 21st century may turn out far better than many in the environmental community thought possible.

The Dark Side of Big Data

Hopes are high for Big Data. GE declares in an online video that the Industrial Internet, a.k.a. the Internet of Things, will bring us "a faster, safer, cleaner, more productive world. And it will be greater than what we've ever done before."

But there is also a growing awareness that important concerns have to be addressed if these hopes are to be realized. If the four V's—volume, velocity, variety and verification—define what Big Data is, then four P's—practicality, privacy, power and privilege—define the hurdles that Big Data must clear in the race to achieve a sustainable future.

Practical challenges are the ones likely to be solved soonest. The primary practical issue to emerge from the conference on "Sustainability in the Age of Big Data," hosted by Wharton's Initiative for Global Environmental Leadership (IGEL), is, ironically, a lack of brainpower.

As Paul Rogers, chief development officer at GE, said in his closing presentation at the IGEL conference, "Big Data exists today in a way that is extremely difficult to understand." Since much of the Industrial Internet data is specific to particular types of machinery, it is often intelligible only to those who designed and built the equipment. It takes deep expertise to use such data to solve problems and find efficiencies. And it requires the additional expertise of computer scientists and others to create software that can render such data useful to non-experts in the future.

The immediate concern is that there simply are not enough experts—engineers, Big Data analysts and computer scientists—to cope with the huge amount of data that is rapidly accumulating. With the right expertise, Big Data can be used to dramatically increase efficiency, enhancing both sustainability and commercial value. But as Alyssa Farrell, director of global sustainability at SAS, said at the Wharton conference, "In order to capitalize on opportunities, companies need more analytical talent in the pipeline."

According to Rogers, "The question is not, 'How do we generate more data?' The question is, 'Is most of the data we have being used for anything meaningful?' And the answer is no."

Also speaking at the Wharton conference, Mark Headd, chief data officer for the city of Philadelphia, pointed to other real-world barriers to the release of data. Much of the historic government data that exists, he pointed out, is inconsistent and incompatible with current databases. "Most of these systems were never designed to release data external to government," he said, "so you need a bridge between the legacy environment and the data environment."

And in government, as in business, concerns about the quality of data often mask control issues. The fact that information is stored in silos guarded by employees who don't want to give up control makes the job harder, Headd said. Department heads, for example, often resist directives to release city data, objecting that the data is not "clean, up to date or suitable for release." According to Headd, "Getting over the apprehension that data is messy is a real obstacle—there's entropy involved."

Another practical issue: How costly and cumbersome it currently is to transmit huge amounts of data wirelessly. The cost is likely to come down as Big Data applications increase and new technology is developed, but for now the terabyte of data generated by jet engines during a flight has to be downloaded by a technician who connects the onboard system to computers on the ground after the plane lands. The problem, says Rogers, is that the wireless "transfer of that data is extremely expensive."

Privacy Concerns

Privacy concerns are all too familiar in the popular press. There have been frequent reports about the U.S. government engaging in massive electronic surveillance of its own citizens and of foreign governments hacking into supposedly secure government and corporate systems.

The New York Times reported recently, "A Russian crime ring has amassed the largest known collection of stolen Internet credentials, including 1.2 billion user name and password combinations and more than 500 million email addresses." This after Eastern European hackers stole 40 million credit card numbers from Target and Vietnamese data thieves got away with "as many as 200 million personal records, including Social Security numbers, credit card data and bank account information from Court Ventures, a company now owned by the data brokerage firm Experian."

Privacy and security are also concerns in the world of sustainability. David Parker, vice president for Big Data at SAP, said at the Wharton conference, "Obviously, data privacy is the biggest big-ticket issue, and Big Data sharing can be undertaken for the greater good, or with wrong intentions." He said that

SAP lobbying of government regulators aims to allow a greater access to and use of data, but with an understanding that lines need to be drawn.

Potential Abuses

The power of Big Data to advance commerce and sustainability can also be abused.

In one example of the concerns about how Big Data will be used, the Farm Bureau Federation is pushing for tighter controls on the use of data that farmers supply to companies they work with. According to Farm Bureau economist Matt Erickson, the worry is that groups opposed to specific practices, such as the use of GMOs, will gain access to supposedly anonymous data, tie them back to specific farms—just as hackers recently linked anonymous Netflix data to specific customers—and use the data against individual farmers.

Michael Lewis wrote a bestseller, *Flash Boys*, about how high-speed traders illegally profited by shaving a few milliseconds off the length of time it took data to transmit from New York to New Jersey. Nothing so high-tech is suspected in commodity markets, but Erickson is concerned that Big Data from farmers could be used to manipulate those markets. Companies with massive amounts of data about everything from fertilizer use to crop yields could use such information to play the market. "If I had all that data I could easily predict the market," says Erickson. "It hasn't happened, but without question it could happen."

Other, subtler abuses of Big Data are also possible. During his conference-opening keynote, Parker related a hypothetical use of customer data that is now possible using data gleaned from a retailer's website and a customer's mobile phone. The retailer, said Parker, could send him a text about a shirt he was looking at online, saying, "Mr. Parker, we now have that shirt in your color, in your size, in a branch local to you; and we understand that you're only a two-minute walk away from that branch." The retailer might go on to use Real Time Offer Management (RTOM) to follow up this message with a text offering a $5 discount if the purchase were to be made within the next 20 minutes.

This service benefits the retailer, the customer and the environment (no packaging, no shipping and no car trip to the local mall), but as Parker noted in passing, it can seem "a little bit Big Brotherish." While the example Parker offered was an "opt-in/opt-out" service, there is the potential for such strategies to be exploited without permission and to move from serving customers into manipulating them—pushing them to buy or use more than they otherwise would, for example.

As CMO of Big Data company Syncsort and IGEL senior fellow Gary Survis indicated in an IGEL blog prior to the Wharton conference, "Clearly … we are embarking on a journey to a new era where there will be an epic battle between those that will use data for good and those that will seek to control it for evil purposes."

The Danger of Manipulation

A related concern surfaced around the idea of using Big Data to motivate sustainable behavior. Speaking about "gamification" at the IGEL conference, Wharton legal studies and business ethics professor Kevin Werbach said games can be used to encourage R&D (a company is likely to generate a lot more research by announcing a competition to invent a more sustainable light bulb, for example, than by simply publishing an Request for Proposal). In a similar way, municipalities can increase recycling rates by making the activity into a kind of game: the town tracks how much a resident recycles and awards points that ultimately lead to a prize of some sort. But one of the dangers is that such strategies can be used to motivate people in unethical ways.

As Werbach noted, "It's easy to use gamification to be manipulative. Do this because it's fun, when there's really some objective that does not necessarily coincide with the player's interests. So it's critical in ethical gamification design to be transparent about those objectives." The challenge facing gamification is how to ensure that the power of Big Data is used to support and not coerce targeted behavior. "It's really important to long-term success," said Werbach, "that people participating feel it's in their best interests and understand the nature of the system, as opposed to it being done without their knowledge."

Privileged Access

Privileged access to Big Data is one of the most difficult challenges facing those in the sustainability space. As Rogers noted, commerce and sustainability both benefit from efficiency. But in many areas of the world, commerce is sparse and markets are too weak to attract serious investment. Yet efficiency and sustainability are even more critical in these areas than they are in the developed world, not simply as ways to improve life, but literally to sustain it.

Virtually all the population growth predicted in the coming decades will take place in developing areas where food and energy are desperately needed, and where Big Data could play a vital role. The ultimate challenge is ensuring that the high hopes for Big Data are realized on a global scale.

It is only natural for difficulties to surface once the initial enthusiasm for a new concept peaks. The Hype Cycle calls it the "Trough of Disillusionment" that follows on the heels of "Inflated Expectations." The issues of practicality, privacy, power and privilege that are now being raised about Big Data are a useful antidote to those inflated expectations, and once they are resolved will lead, in all likelihood, to greater enlightenment and ultimately to a more sustainable world.

Decarbonizing Development: Three Steps to a Zero-Carbon Future

Marianne Fay, Stephane Hallegatte, Adrien Vogt-Schilb, Julie Rozenberg, & Ulf Narloch

Stabilizing climate change entails reducing net emissions of carbon dioxide (CO_2) to zero. CO_2 stays in the atmosphere for hundreds, if not thousands, of years. As long as we emit more than nature can absorb in its sinks (oceans, forests, and other vegetation), concentrations of CO_2 in the atmosphere will keep rising, and the climate will keep warming. And the decisions we make now will determine the planet's climate for centuries.

The latest science also tells us that we need to reach zero net emissions by 2100 to stabilize climate change around the 2°C target above preindustrial temperatures that has been agreed by governments as the maximum acceptable amount of warming. Relaxing the target to 3°C would make little difference in the policies needed, although a 2°C target would require more aggressive, earlier action.

But can we envisage a world in which economic activities have been made completely carbon neutral by the end of the century? Here, we should emphasize that carbon neutrality or decarbonization does not imply no emissions whatsoever. Positive emissions in some sectors and some countries can be offset, to some extent, through natural carbon sinks and negative emissions in other sectors and countries. So decarbonization means zero net emissions of CO_2—as well as the stabilization of emissions of short-lived greenhouse gases such as methane that dissipate in the atmosphere in days, weeks, or decades.

The latest report of the Intergovernmental Panel on Climate Change (IPCC) identified many possible pathways to reach carbon neutrality by the end of the century. All require acting on four fronts: (a) decarbonization of electricity; (b) massive electrification (using that clean electricity) and, where that is not possible, a switch to lower-carbon fuels; (c) greater efficiency and less waste in all sectors; and (d) improved carbon sinks (such as forests, vegetation, and soil).

In practical terms, what does this mean for countries, especially developing countries that are already struggling to reduce poverty and achieve prosperity? Many are unable to keep up with the investments to satisfy the basic needs of their citizens, let alone the efficient cities, roads, housing, schools, and health systems they aspire to create. At the same time, the fact that much of their infrastructure is yet to be built means opportunities exist to act early and gain efficiency. Thus, the pursuit of a low-carbon transition must be integrated into the overall development agenda: the goal is not just to decarbonize, but to decarbonize development.

The aim of this report is to take this lofty goal of zero emissions by 2100 and examine what it means in terms of today's policy making for development. It does not discuss whether or why to stabilize climate change, or at which level we should do so. Our starting point is the 2°C goal set by the international community. We begin by examining how planning can help lay the foundation for both a stable climate and a good development path. Next, we explore how countries can create the right enabling environment so that the needed technology, infrastructure, and financing are available. Finally, we discuss how countries can carefully manage the transition, given the vital role that the political economy will play.

The message of this report is that to decarbonize development, and to do so by 2100, three broad principles must guide countries' low-carbon efforts:

1. Plan ahead with an eye on the end goal.
2. Go beyond prices with a policy package that triggers changes in investment patterns, technologies, and behaviors.

3. Mind the political economy and smooth the transition for those who stand to be most affected.

Planning for a Low-Carbon Future: What We Need to Do Now Depends on the End Goal

A key reason scientists believe it is possible to achieve full decarbonization by 2100 is that they have looked at pathways that would do so. Those pathways are derived from various energy and economic models that examine what it would take to achieve decarbonization under a number of different scenarios of economic growth and technological innovation. As mentioned earlier, what all models and modelers agree on is that action will be needed on four fronts:

- Decarbonizing the production of electricity
- Undertaking massive electrification (to increase reliance on clean electricity) and, where not possible, switching to cleaner fuels
- Improving efficiency and reducing waste in all sectors
- Preserving and increasing natural carbon sinks through improved management of forests and other vegetation and soils

The question is when to begin and at what speed to proceed. Fortunately, there is no need for all countries to follow the same path or rhythm. Weaker efforts early on can be offset (up to a point) by greater efforts later, and more effort now means less will be needed tomorrow. And since decarbonization is a global goal, greater efforts by a richer or more able country can offset less intense efforts by a country with less capacity. As the IPCC argues, multiple pathways can lead to decarbonization. However, the key to feasibility is affordability, and affordability requires early action.

Early Action

Early action is vital for two reasons. First, it is cost-effective, because it allows countries to take advantage of natural opportunities to green their capital as it is retired or as it is first built. The alternative is delays, which imply the continued construction of dirty power plants and other capital that create "committed emissions." For example, the fossil-fueled power plants built in 2012 alone will emit some 19 billion tons of CO_2 over their expected 40-year lifetime, more than the annual emissions of all operating fossil fueled power plants in 2012. Retiring them early is possible, but costly. The models reviewed by the IPCC find that if mitigation is postponed until 2030, costs would rise an average 50 percent for the 2030–50 period, and 40 percent for the longer term (2050–2100).

... early action is prudent because delays can result in lock-ins and the loss of options.

Second, early action is prudent because delays can result in lock-ins and the loss of options. A failure to invest in developing new technologies such as carbon capture and storage now may mean they are not available by midcentury when they are needed. And trying to retrofit a low-density city to make it more carbon efficient and suitable for public transit is extremely difficult, as city managers around the United States are finding out.

Thus, the pledges made by member countries of the United Nations Framework Convention on Climate Change in Cancún in 2010 are worrisome: they amount to such modest reductions in the short run that they would require annual cuts in emissions of 6 percent per year from 2030 onward to achieve the globally endorsed stated objective of 2°C. Historically, such rapid declines have occurred only during economic collapses, such as the fall of the Soviet Union. The highest decarbonization ever achieved in a planned fashion was 4.5 percent per year, when France deployed its nuclear energy program.

Some will say that waiting can also save money: as technologies evolve, they improve, become more affordable, and open up new options. But if everyone waits, those technologies will not be invented, and they certainly will neither improve nor become more affordable. And in the face of development pressures, waiting is not always an option. Things get built anyway—but incorrectly, as is occurring in much of the urbanization taking place in developing countries.

So someone has to start. And when it comes to new technologies, the richer countries must lead in funding frontier innovation and creating the demand that allows for largescale deployment and lower costs. Thus, the massive expansion in solar energy in Germany has been critical in reducing the cost of solar panels. But even very poor countries can identify early action that makes sense within their overall development strategy.

What exactly does early action entail? And how should policy makers make decisions in situations of uncertainty, multiple worldviews, and competing objectives? We would argue that countries should focus on actions that offer synergies with short-term development goals or that are urgent:

- *Synergies*. Many mitigation options (such as public transit, cleaner energy, and energy efficiency) offer immediate and local economic and welfare benefits. Prioritizing those options will help ensure that climate considerations are well integrated into countries' development plans and will increase political acceptability. For example, some analyses suggest that the health benefits of cleaner air alone would exceed the cost of mitigation in many regions at

least until 2030 (Shindell et al. 2012; Thompson et al. 2014).

- *Urgency.* Some mitigation options are associated with high technical inertia (meaning that they carry a risk of lock-in, irreversibility, or higher costs if action is delayed)—such as unplanned low-density urban expansion or the cutting down of old-growth forests. Some abatement actions will take time and will need to be implemented early (such as research and development for the needed technologies and support for their deployment). For them, action is urgent. Otherwise, action can be postponed for measures that create hard trade-offs with other development goals in poor countries.

Planning Ahead

The good news is that a number of planning tools are available to help countries—poor and rich alike—devise an appropriate decarbonization plan. But the key is to use these tools with an eye on the end goal for a number of reasons.

First, keeping an eye on the end goal will help poorer countries align development and poverty alleviation with climate policies. Higher emissions from better energy access or structural change in poor low-emission countries or regions should not be a concern as long as irreversible carbon lock-in is avoided (possibly by using urban plans and well-enforced building norms). Indeed, those countries should use low-cost options to maximize poverty reduction, which may include coal where solar power or hydropower is not possible or is too expensive. That said, they would still benefit from capturing the potential for low-cost renewable power (such as hydropower), avoiding energy waste, improving air quality, and creating a cost-efficient economic system (with appropriate energy pricing and performance standards).

In addition, for all countries, a focus on short-term targets (such as 2030) without considering long-term ones (such as for 2050 and beyond) would lead to emission reductions based on the cheapest options—which may lack the potential to achieve complete decarbonization. It could thus result in a carbon-intensive lock-in, making it much more expensive to achieve the long-term objective.

Take the case of a low-carbon strategy analysis done for Brazil. For example, the optimal strategy for a 2020 end goal makes greater use of marginal actions that are cheap and easy to implement but that have a limited potential (improved energy efficiency in refineries). In contrast, the optimal strategy for a 2030 end goal entails more ambitious actions that are more expensive and take longer to implement but that have the potential to contribute to deeper decarbonization. Thus, if the goal is simply a 10 percent reduction in 2020, limited use should be made of investments in subways, trains, and waterways—although those investments are critical to ensure the feasibility of a 20 percent reduction by 2030.

The key to designing an emission-reduction plan that accounts for the long term is to consider three characteristics of each option: cost, mitigation potential, and time needed to implement. Options with "negative costs" (such as energy efficiency) or large development co-benefits should be implemented as soon as possible. Options that are expensive but that are slow to reach their full potential (such as transport) may also have to get started early in order to reach the long-term goal. In contrast, cheaper options may be delayed without threatening the long-term goal.

With this information, governments can design operational short-term targets to ensure that they make progress in all sectors. For instance, a target may be to produce 30 percent of electricity from renewable sources by 2030, to drive cars that emit less than 80gCO_2 per kilometer by 2025, or to use wood materials—from sustainably managed forests—instead of steel and cement in half of all new buildings by 2035. This sectoral approach has an advantage over economy-wide emission goals, because the latter could be achieved with marginal actions that do not contribute sufficiently to meeting the long-term objectives.

Enabling the Transition with a Policy Package That Is Efficient, Acceptable, and Credible

Good planning is important, but so are incentives and policies that ensure planned actions are implemented and projects are financed. Thus, carbon pricing is a critical policy, as it addresses a major market failure—the failure to price the environmental damage caused by greenhouse gases. However, a multiplicity of market and government failures comes together to make climate change a complex problem to solve. So pricing is necessary, but not sufficient, especially if a low-carbon strategy is to be politically acceptable and credible enough to trigger the kind of long-term investments that are needed. Also needed are complementary measures to make individuals and firms more responsive to prices—or substitutes for prices when they are ineffective.

Getting Prices Right—
Good Economic and Fiscal Policy

Schemes to get prices right have the great advantage of raising revenues in an economically and fiscally efficient way, making them good fiscal policies, in addition to their environmental benefits. That advantage is obvious with the elimination of environmentally harmful subsidies, but it is also the case for carbon pricing—whether taxes or cap and trade (provided that permits are sold or auctioned).

Getting prices right includes reforming fossil-fuel subsidies—which reached about $548 billion in 2013, according to the International Energy Agency, a number that is likely to be an underes-

timate. Even so, this sum still averages 5 percent of gross domestic product and 25–30 percent of government revenues among the 40 mostly developing countries for which it was calculated (IEA 2014). Other environmentally harmful subsidies, such as agricultural support schemes that incentivize the overuse of pesticides and fertilizer and excessive emissions, need to be reformed as well.

Encouragingly, good progress has been made in recent years. Over the past two years, more than 25 countries, many in Asia, have significantly reformed their fossil-fuel subsidies. Indonesia abandoned a four-decades-old policy of subsidizing gasoline, India liberalized diesel prices and raised fuel taxes, and Malaysia eliminated subsidies on gasoline and diesel. That trend is likely to accelerate with the drop in oil prices, which makes it easier to reform subsidies for oil importers and creates pressure for reform among oil exporters.

As for carbon pricing, it is also gaining momentum—with some 39 national and 23 subnational jurisdictions globally having implemented or scheduled to implement carbon-pricing instruments. For example, China has seven local emission-trading pilots to test possible approaches to a national scheme, and British Columbia, one of Canada's fastest-growing provinces, introduced a carbon tax in 2008.

Carbon pricing offers a potential "double dividend" by providing both environmental benefits and the possibility of reducing more distortionary taxes (such as those on labor or capital) by recycling carbon revenues. In addition, carbon constitutes an excellent tax base, as carbon sources are concentrated and difficult to evade. In the United States, for example, tax collection covering 80 percent of emissions could be accomplished by monitoring fewer than 3,000 points (refineries, coal mines, and natural gas fields) (Metcalf and Weisbach 2009). In Sweden, which has had a carbon tax since 1992, tax evasion is less than 1 percent for carbon, much less than for the value added tax. In the United Kingdom, evasion on energy taxes is about 2 percent, much lower than the 17 percent for income tax. That is a substantial advantage for the many developing countries that struggle with tax evasion—and the wedge it introduces between the formal and informal sectors.

Yet another way to get prices right is with performance-based payments, which can be used to create incentives to preserve or increase carbon sinks, such as forests and soil. Currently, more than 300 payments for ecosystem service schemes have been established worldwide, many of them for carbon sequestration.

Policies to Complement Prices or to Substitute for Them When They Are Ineffective or Unchangeable

But getting prices right is not enough to ensure that low-carbon policies are acceptable, credible, and effective. Instead, policy packages need to take into account the following issues:

- *Are prices an effective instrument to trigger the desired change?* The answer depends on such factors as the availability of low-carbon alternatives or the need for long-term credibility. For instance, a carbon tax is sufficient to trigger fuel shifts in the energy sector (maybe from coal to gas) but may not be enough to generate frontier innovation in the energy or automobile industry.
- *Is it possible to change prices?* Whether prices can in fact be changed enough to trigger a response depends on the political or social acceptability of a price change. The issue may be concerns about the impact on poor people or the need to manage powerful lobbies fiercely opposed to reform.

Those two issues are linked. If price effectiveness is low, reducing emissions to a given level would require a significant price hike, which is more likely to hurt some groups or industries and is thus less acceptable. It is also possible that prices can be changed without leading to the expected impact on emissions because of missing markets, lax compliance, lack of information, or behavioral biases and cognitive failures. As a result, the policy package will need a battery of instruments—such as research and development and innovation support, performance standards and fiscal incentives for investments, financial instruments, and social policies and compensation—to create an enabling environment for the low-carbon policies to work. This requires efforts on the following fronts.

Ensure needed technologies. A first challenge is to ensure that the needed technologies exist (a pure innovation problem) and are available at scale and at a competitive cost (a deployment problem). Existing technologies are sufficient to keep the world on a 2°C path up to about 2050, but thereafter, staying on track will require deploying technologies that are currently barely at the pilot stage or do not even exist. And the claim that a 2°C path is affordable relies on the assumption that the needed technologies will be available.

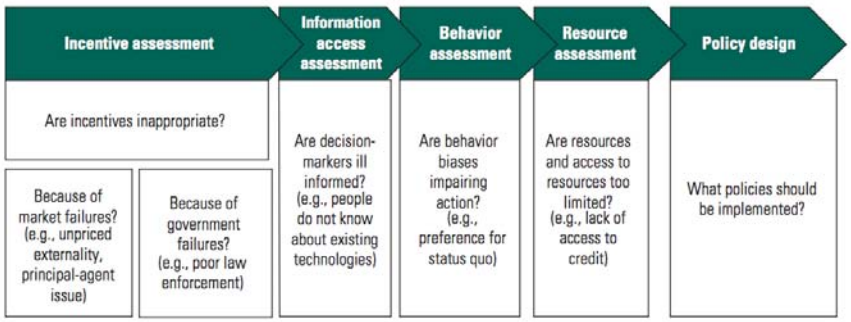
Green innovation suffers from a double market failure—environmental externalities and the same "knowledge externality" that plagues all innovation (new knowledge can be acquired at low cost by competitors). But a combination of a carbon price and broad public support for innovation will not be sufficient. Specific support toward green innovation is essential. Economic actors prefer to innovate where they have innovated before and where there is a combination of well-known demand and mature markets—a bias that favors marginal innovation in traditional domains, not radically new green innovation. Also, a carbon price is unlikely to be a sufficiently credible instrument to justify the kind of long-term, risky investments that are required for green frontier innovation. Policy makers should kick-start the transition either by temporarily

supporting investments in low-carbon technologies (Acemoglu et al. 2012) or by imposing additional regulations or performance standards (Rozenberg, Vogt-Schilb, and Hallegatte 2014). In addition, governments may even need to target specific green technologies. That specificity is justified in the case of solar, which is still more expensive than wind energy in most markets but has greater potential for reducing cost through economies of scale and for addressing the clean-energy challenge. Because of solar's current relatively high costs, it is unlikely to be massively deployed with only horizontal (nontargeted) support to carbon-free electricity production or a carbon price.

To ensure that green technologies are invented and deployed at scale, countries might supplement carbon prices (or substitute for them where they cannot yet be implemented) with a number of instruments.

- Performance standards—such as those commonly used for cars in China, the European Union, and North America, and energy-efficient lighting or building codes (windows, ventilation, or heating and cooling systems).
- Fiscal instruments—such as auto *feebates*, which combine a surcharge (fee) on energy-inefficient cars with a rebate on more energy-efficient ones (used, for example, in a number of European countries) or a value added tax exemption for appliances or energy-efficient lighting (used, for example, in China, Ghana, and Tunisia).
- Mandates—such as renewable portfolio standards that require electricity providers to include a minimum share of clean energy in their output mix. Mandates have been used throughout the world, notably in Chile, China, Germany, and many U.S. states.
- Trade policies—such as cutting tariffs on green goods, such as solar panels, wind turbines, and energy-efficient lightbulbs as Asia Pacific Economic Cooperation countries recently agreed to do—to ensure that countries, firms, and households can access the best technologies that are available globally at an acceptable cost.
- Better institutional capacity and law enforcement—such as clarifying property rights and increasing controls and fines. In Brazil, enforcing and clarifying existing laws have proved to be an effective, low-cost strategy to reduce deforestation.

Figure 1. How to Assess the Obstacles to Low-Carbon Solutions



Source: Adapted from World Bank (2013).

Ensure the needed infrastructure. Providing the needed infrastructure is critical for both the effectiveness of low-carbon strategies and the political acceptability of carbon pricing. For example, imposing significant fuel taxes has proved a lot more difficult in the United States than in Europe, in part because a much larger share of U.S. voters live in places unserved by easy, convenient public transportation. Infrastructure also makes a carbon price more effective by making demand more elastic to price changes. A modeling exercise for Paris shows that public transport reduces by half the carbon tax needed to achieve a given emission reduction (Avner, Rentschler, and Hallegatte 2014). Similarly, some countries have struggled to ensure that the needed electricity transmission lines and network capacity are in place to handle increased shares of renewable energy.

Account for behavioral biases and other obstacles to changing habits. But even with price incentives and available alternatives, people may still stick to old habits for a variety of reasons (Figure 1). They may do so because incentives are not effective due to some market failure (for example, landlords who buy inefficient equipment because tenants pay the electricity bills) or because the incentives are just not enforced. Many countries have enacted energy-efficiency requirements for new buildings without implementing measures to enforce them.

People may also not be aware of better alternatives. Labels and certification schemes can easily provide the information consumers need to influence production technologies and promote sustainable natural resource management (for instance, for forest management).

Evidence abounds of people being "tempted" by the low price of an appliance and not paying attention to the lifetime cost of a purchase. And people tend to stick to the default option. Such behavioral biases can in fact be used to increase the adoption of green technologies. For example, a German energy company found that 94 percent of its customers stayed with the green (and more expensive) option when it was set up as the default, and only 4 percent opted for a cheaper one (the remaining 2 percent either changed suppliers or opted for a more expensive green option).

Getting the Finance to Flow—Which Will Take More than Carbon Pricing and Green Finance

Making the needed infrastructure and technologies available requires financing. In fact, most developing countries struggle with financing infrastructure provision and technological development and deployment even without the low-carbon objective. Fiscal limits constrain self-financing and overseas development aid, so the bulk of the finance challenge lies with making sure that developing countries can access more private (domestic and international) resources for long-term investment. That financing constraint extends to developing-country firms, especially small and medium-sized firms, many of which would need to invest in energy-efficient and low-carbon equipment and to access technologies adapted to local conditions.

The challenge thus is twofold: (a) to increase financing for investments in developing countries and in long-term projects, notably infrastructure, and (b) to increase the share of those investments that goes toward green projects. The low-carbon part of that challenge is an important one but should not be overestimated. According to the models reviewed by the IPCC, estimates of needed additional investment average about $400 billion per year, or about 0.5 percent of global gross domestic product. Another estimate places it at about $300 billion out of a yearly average of $6 trillion needed for overall investments by 2030 (NCE 2014). Of course, investment needs could be higher or lower, depending on how technologies develop, how early we start, and how efficient the transition is.

That amount is far from negligible, but it is a small share of the total needed anyway for development and growth. Further, those investments would generate co-benefits beyond reduced climate change impacts, such as reduced air pollution that would avoid 1 million premature deaths annually by 2050 (West et al. 2013), improved agricultural productivity, increased access to public transit, reduced congestion and traffic accidents, and greater energy security for fossil-fuel importers.

Nevertheless, the point remains that the real challenge is likely to be access to financing, rather than affordability per se. Even if the absolute cost is modest relative to overall resources and represents a small increase in overall needs, financing could be difficult for countries that already struggle to generate the needed basic investments.

... investments would generate co-benefits beyond reduced climate change impacts....

How can the existing financing gap be closed? Recommendations typically fall into two broad categories: making the investments more attractive and leveraging private resources to make the most of available capital. Those approaches involve well-known steps, such as improving the investment climate (making sure that regulations are clear and predictable and that the rule of law and property rights are enforced), developing local capital markets, and providing a pipeline of *bankable* projects—something that has proved difficult for many countries and is now recognized as an even greater challenge than a lack of capital. But closing the financing gap most likely also requires a deep reform of the international monetary system, including financial sector risk assessment and stress tests that have a longer time horizon and consider a broader set of risks (such as carbon exposure), along with compensation packages more attuned to long-term returns and risks.

In addition, low-carbon investments present a number of issues that must be addressed with targeted tools. Initial investments for low-carbon projects tend to be a higher share of total costs than for conventional projects, making them more sensitive to financial costs. Low-carbon projects tend to carry greater technology risk, simply because they typically rely on newer technologies. They also have higher policy risks, to the extent that they may be more dependent on government policies (such as a carbon price). In some cases, they may just be new and different, requiring investors and project managers to innovate, and may possibly lead to a *perception* of higher risk.

Thus, we see the need for rebalancing both the actual and perceived risk-adjusted returns differential between brown and green projects. The most powerful way of reducing risk perception is to make progress toward global agreements and the design of an international architecture to support climate change mitigation. That approach will go a long way toward convincing economic actors that the future will be carbon neutral. In addition, adding environmental considerations into banks' due diligence standards would help make the financial system more sensitive to the risks embedded in *carbon-entangled* investments. As an example, the Bank of England recently agreed to examine the vulnerability that fossil-fuel assets could pose to the stability of the financial system in a carbon-constrained world.

In addition, the development of green financial products (such as green bonds) is helping mainstream low-carbon investments, connect green project developers with possible investors, and overcome the behavioral bias toward conventional investments. The green bond market has experienced rapid growth—reaching some $35 billion in 2014, up from $12 billion the year before—thereby contributing to the re-

allocation of resources from traditional investments to low-carbon ones. It is gaining further momentum with the development of green bond indexes by heavyweights such as Standard & Poor's, Bank of America, and Merrill Lynch.

With regard to high financial costs linked to low-carbon projects, they can be reduced through cofinancing by governments or multilateral development banks that may want to take on the *green* part of the risk. Investments can also be redirected with bank regulations that encourage commercial banks to invest in low-carbon projects. The rationale for such policies comes from the diverse mandates of central banks, which range from simply achieving price stability to contributing to wider economic and social objectives.

Managing the Transition: Protecting Poor People and Avoiding the Potential Pitfalls of Reforms

The goal of the transition is to decarbonize development rather than just reduce emissions. Hence, reforms must contribute to poverty alleviation and shared prosperity. And as with any major transition, the political economy of reforms must be managed with allowances made to those with a stake in the status quo and with good communication of the goals and benefits of the reform.

Ensuring Poor People Benefit

Fossil-fuel subsidies and artificially low energy prices are not efficient ways to boost competitiveness or help poor people. Such measures drain fiscal coffers, hurt the environment, slow the deployment of greener technologies, and chiefly benefit nonpoor people. A review of fossil-fuel subsidies in 20 countries shows that the poorest 20 percent of the population receive on average less than 8 percent of the benefits, whereas the richest 20 percent capture some 43 percent (Arze del Granado, Coady, and Gillingham 2012).

But even if removing fossil-fuel subsidies and adopting carbon pricing improve equity, those measures will also increase the price of energy and other goods (such as food), thereby reducing poor households' purchasing power. Further, higher prices for modern energy could lock poor people into using solid fuels for cooking, with impacts on health, gender balance, and children's access to education (women and children spend a disproportionate amount of time collecting traditional fuels and spend more time exposed to indoor pollution). Also, industrialization has been a powerful force for poverty reduction in many countries and could theoretically be slowed by higher energy prices.

The goal of the transition is to decarbonize development rather than just reduce emissions.

It is therefore critical to use the savings or new proceeds generated by climate policies to compensate poor people, promote poverty reduction, and boost safety nets. One way to do that is by recycling revenue through tax cuts and increasing transfers to the population—as British Columbia did to ensure that its reforms were progressive (Beck et al. 2014). Similarly, the Islamic Republic of Iran implemented a quasi-universal cash transfer (about $45 per month per capita) as part of its energy reforms (IMF 2013). A modeling exercise carried out using data from developing countries shows that taking $100 away from fossil-fuel subsidies and redistributing the money equally throughout the population would on average transfer $13 to the bottom quintile and take away $23 from the top quintile.

Another way to ensure that poor people benefit is with in-kind measures. Ghana's 2005 fossil-fuel subsidy reform increased the price of transport fuels by 50 percent but also included an expansion of primary health care and electrification in poor and rural areas, the large-scale distribution of efficient lightbulbs, public transport improvements, and the elimination of school fees at government-run primary and secondary schools (IMF 2013; Vagliasindi 2012).

Redistribution has also been shown to significantly increase the odds of reforms succeeding. A review of reforms in the Middle East and North Africa classifies all reforms with cash and in-kind transfers as successful, as opposed to only 17 percent of the cases without (IMF 2013; Sdralevich, Sab, and Zouhar 2014).

Similarly, care must be taken in the design of land-use-based mitigation policies to ensure that they do not restrict access to land for the poorest people and that they respect and strengthen customary rights. A good example is Brazil's Terra Legal program, which is offering formal recognition to indigenous land and granting land titles to some 300,000 smallholders. Without such a program, REDD+ policies may benefit only richer landowners. In addition, payment for ecosystem services can directly increase the incomes of poor land users. Such programs in Brazil, Ecuador, and Guatemala aim to support poor communities, although so far evidence of their impact is limited. The hope is that by 2030, an estimated 25 million to 50 million low-income households will benefit if carbon payments are fully developed and pro-poor participation conditions secured (Milder, Scherr, and Bracer 2010).

Managing the Political Economy of Reform without Getting Captured by Vested Interests

Worries about large-scale deindustrialization and job losses—which play a big role in debates on carbon tax and cap-and-trade systems—may be overblown. Evidence from developed countries suggests that there are no discernible impacts on productivity and jobs from introducing cost-increasing environmental regulations or pricing schemes.

Indeed, pollution abatement costs represent only a small fraction of production costs for most industries, and factors such as the availability of capital and skilled labor or proximity to markets are much more important determinants of firm location and competitiveness (Copeland 2012). In contrast, resources raised by carbon-pricing schemes can contribute to attracting more jobs and investments by improving more important factors, such as education and workers' skills or infrastructure, and by reducing capital and labor taxes that are more distortive than carbon pricing.

However, what is valid for relatively modest environmental regulations may not be true for stricter policies. A low-carbon transition entails a shift away from carbon-intensive sectors and technologies toward low-carbon ones. In the short to medium term, that transition means reallocating capital, labor, and rents. It cannot be done without negative impacts on some asset owners and workers. Further, those impacts may be spatially concentrated in regions that specialize in energy-intensive or extractive industries, such as steel production or coal mining.

A key question is the extent to which those who stand to be most affected need to be compensated or protected. The answer can be based on ethical considerations: poor people are vulnerable to those changes and have a lower capacity to adjust to price changes; and some (poor or non-poor) stand to lose their investments and livelihoods because the rules of the game have changed, not because they were willfully doing the wrong thing. But there is also a pragmatic argument: compensation may be needed for political economy reasons. Climate policy gains tend to be diffuse across economic actors, and the benefits of climate change stabilization are intangible avoided losses, which take place mostly in the future. Those characteristics do not help create a vocal group of policy supporters (Olson 1977). In contrast, policy costs tend to be visible, immediate, and concentrated over a few industries, which may have a de facto ability to veto the reform.

A number of steps can help smooth the transition and avoid concentrating losses (either spatially or within a particular interest group). One option is to start the reforms with regulations such as performance standards that apply only to new capital. This approach is less efficient from an economic point of view than immediately introducing a carbon price. But it has the advantage of putting the economy on the right path without hurting owners of existing capital (hence, reducing resistance). Further, it creates a constituency for change, as business owners are less likely to lobby for repeal of a carbon law or against the subsequent introduction of a carbon tax if they have already invested in the new, cleaner capital. So the impact of a regulatory approach can extend past the existing election cycle. This approach also delivers emission reductions and prepares the economy for the introduction of a carbon price or the removal of fossil-fuel subsidies, as it progressively transforms the economic system into a more efficient one that remains competitive with appropriate energy prices (Rozenberg,Vogt-Schilb, and Hallegatte 2014).

Another solution is to adopt compensation schemes. Strong social protection systems play the role of horizontal compensation systems, since they protect households and individuals against economic shocks. Specific instruments can also be implemented, as in Japan's support for traditional industries (such as textiles and shipbuilding) in the 1960s and 1970s (Krauss 1992; Peck, Levin, and Goto 1987). The U.S. Trade Adjustment Assistance Program also provided reemployment services to displaced workers and financial assistance to manufacturers and service firms hurt by import competition. Experience from trade liberalization has shown that support such as wage subsidies to encourage hiring in the expanding sectors and unemployment insurance for the displaced workers can effectively help mitigate most of the losses and have generally modest costs (Porto 2012; Trebilcock 2014).

Of course, governments make mistakes when trying to smooth the transition—by erring when they try to *pick the winners*, by supporting declining sectors beyond what is efficient, or by being captured by special interests. Thus, they have often taken steps to help reduce the likelihood of costly failures and capture. For example, East Asian governments used trade competitiveness as a marker for their industrial policies: public support was swiftly cut for industries that could not compete in international markets. Such a clear test may be more difficult for low-carbon technologies that by nature depend on a government policy to be attractive (whether carbon price or a regulation), but, in general, the following can help (Rodrik 2013):

- Clear and transparent criteria that determine when public support should be terminated
- An institutional design that balances flexibility (needed to adjust policies when new information is available) and predictability (so that long-term investment is possible)
- Transparency and public accountability—so that the beneficiaries of the policies are the public rather than the firms that are being supported

And Finally, Communication Matters

The political acceptability of reforms does not depend just on their impact. The *perception* of impact also matters.

Thus, reforms must be anchored in a good understanding of who the stakeholders are and the nature of their fears and concerns.

Take the case of fossil-fuel subsidy reforms. A 2014 survey in the Arab Republic of Egypt showed that a whopping 70 percent of the population did not know the scale of the subsidy; worse, in Morocco, a 2010 survey found that 70 percent were unaware that energy was in fact subsidized. Thus, it was vital to raise awareness about the fact that the subsidy absorbed a huge part of government revenues (39 percent in Egypt and 17 percent in Morocco)—and the many other things that the government could achieve with those resources. Where reforms have been successful, they have often been accompanied by a communication campaign that spoke to citizens' concerns about "what's in it for me?" For example, the message of the Islamic Republic of Iran's 2010 fuel reform campaign was that the reform aimed to switch subsidies from *products to households.*

Wording also matters. Calling a carbon-pricing scheme a carbon tax suggests that its purpose is primarily to raise revenues rather than to improve welfare by creating incentives to produce and consume fewer carbon-intensive products. In fact, most schemes avoid using *carbon*, *climate*, or *tax* in their official labels, instead opting for terms such as *fee*, *premium*, or *surcharge* (Rabe and Borick 2012).

Finally, the broader benefits of reform must be communicated. In Germany, a study found that businesses were aware of higher energy taxes but not of the associated cuts in payroll taxes. But once they were informed, they were less likely to disapprove of the energy tax (Dresner et al. 2006).

References

Acemoglu, D., P. Aghion, L. Bursztyn, and D. Hemous. 2012. "The Environment and Directed Technical Change." *American Economic Review* 102 (1): 131–66.

Arze del Granado, F. Javier, D. Coady, and R. Gillingham. 2012. "The Unequal Benefits of Fuel Subsidies: A Review of Evidence for Developing Countries." *World Development* 40 (11): 2234–48.

Avner, P., J. E. Rentschler, and S. Hallegatte. 2014. "Carbon Price Efficiency: Lock-In and Path Dependence in Urban Forms and Transport Infrastructure." Policy Research Working Paper 6941, World Bank, Washington, DC.

Beck, M., N. Rivers, R. Wigle, and H. Yonezawa. 2014. "Carbon Tax and Revenue Recycling: Impacts on Households in British Columbia." Working paper, Laurier Centre for Economic Research and Policy Analysis, Waterloo, ON.

Copeland, B. 2012. "International Trade and Green Growth." World Bank, background paper for the Green Growth Knowledge Platform conference, Mexico City, January 12–13.

Dresner, S., L. Dunne, P. Clinch, and C. Beuermann. 2006. "Social and Political Responses to Ecological Tax Reform in Europe: An Introduction to the Special Issue." *Energy Policy* 34 (8): 895–904.

IEA (International Energy Agency). 2014. *World Energy Outlook: 2014*. Paris: IEA.

IMF (International Monetary Fund). 2013. *Energy Subsidy Reform: Lessons and Implications*. Washington, DC: IMF.

Krauss, E. S. 1992. "Political Economy: Policymaking and Industrial Policy in Japan." *PS: Political Science & Politics* 25 (1): 44–57.

Metcalf, G. E., and D. Weisbach. 2009. "The Design of a Carbon Tax." *Harvard Environmental Law Review* 33: 499.

Milder, J. C., S. J. Scherr, and C. Bracer. 2010. "Trends and Future Potential of Payment for Ecosystem Services to Alleviate Rural Poverty in Developing Countries." *Ecology and Society* 15 (2): 4.

NCE (New Climate Economy). 2014. *Better Growth, Better Climate: The New Climate Economy Report*. Washington, DC: NCE.

Olson, M. 1977. *The Logic of Collective Action: Public Goods and the Theory of Groups*. Cambridge, MA: Harvard University Press.

Peck, M. J., R. C. Levin, and A. Goto. 1987. "Picking Losers: Public Policy toward Declining Industries in Japan." *Journal of Japanese Studies* 13 (1): 79–123.

Porto, G. G. 2012. "The Cost of Adjustment to Green Growth Policies: Lessons from Trade Adjustment Costs." Policy Research Working Paper 6237, World Bank, Washington, DC.

Rabe, B. G., and C. P. Borick. 2012. "Carbon Taxation and Policy Labeling: Experience from American States and Canadian Provinces." *Review of Policy Research* 29 (3): 358–82.

Rodrik, D. 2013. "Green Industrial Policies." Presentation at the Economics of Green Growth

Workshop, Grantham Research Institute and Global Green Growth Institute, London, October 1.

Rozenberg, J., A. Vogt-Schilb, and S. Hallegatte. 2014. "Transition to Clean Capital, Irreversible Investment and Stranded Assets." Policy Research Working Paper 6859, World Bank, Washington, DC.

Sdralevich, C. A., R. Sab, and Y. Zouhar. 2014. *Subsidy Reform in the Middle East and North Africa: Recent Progress and Challenges Ahead*. Washington, DC: International Monetary Fund.

Shindell, D et al. 2012. "Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security." *Science* 335 (3065): 183–89.

Thompson, T. M., S. Rausch, R. K. Saari, and N. E. Selin. 2014. "A Systems Approach to Evaluating the Air Quality Co-Benefits of US Carbon Policies." *Nature Climate Change* 4: 917–23.

Trebilcock, M. J. 2014. *Dealing with Losers: The Political Economy of Policy Transitions*. New York: Oxford University Press.

Vagliasindi, M. 2012. "Implementing Energy Subsidy Reforms: An Overview of the Key Issues." Policy Research Working Paper 6122, World Bank, Washington, DC.

West, J. J. et al. 2013. "Co-Benefits of Mitigating Global Greenhouse Gas Emissions for Future Air Quality and Human Health." *Nature Climate Change* 3 (10): 885–89.

Water in the West

Andrew Fahlund, Min L. Janny Choy, & Leon Szeptycki

Introduction

The Western United States is a diverse region of the country, with little in common between places like Cody, Wyoming and Palo Alto, California. One condition common to the region—with the exception of a few coastal communities—is aridity. It seems odd to characterize an entire region by what it lacks, but water has always been the most consistent and frequently cited tie that binds the West.

Although a long history of papers, reports, and books have analyzed issues around western water,[1] the last official comprehensive examination of the subject was published 15 years ago. In 1996, Congress chartered the Western Water Policy Review Advisory Commission (Commission) to publish a report, Water in the West: Challenge for the Next Century (1998 Report).[2] A central question the authors were tasked to answer was, "Are the current uses of water and water related resources sustainable and if not, what institutional changes will enhance sustainable management?" This effort was modeled after another comprehensive study of the nation's water resources from 1973. The Commission explained that they "opted to build from that study, focusing on the important, often unanticipated developments since." We have similarly elected to build from where the most recent effort left off. While not nearly as expansive or as well resourced,[3] this paper will give the reader some insights into how western water management is shaped and is shaping the region today and in the near future, with a particular focus on what has changed over the last 15 years.

The Setting

Water is scarce throughout most of the western United States. It is a vast area of mountain ranges, deserts, canyons, and grasslands with very little precipitation, except for pockets in the Pacific Northwest, Rockies, and Sierra Nevada. The West has typically been defined by the 100th Meridian. On average, the region west of this longitude—which runs down the center of the Great Plains—receives less than 20 inches of annual rainfall, whereas more than 20 inches of precipitation falls east of this line. Another defining characteristic of the West is open space. While water is scarce, public lands are abundant.[4] Many western states have significant federal land ownership: for example, 81% of Nevada, 67% of Utah, 62% of Idaho, and 48% of California are federally owned and managed.[5] The abundance of public lands enables a wide range of activities, from energy development and agriculture to tourism and conservation, but perhaps most significantly, it has uniquely enabled a system of large water developments throughout the West.

This article is an excerpt from sections 1-3 of "Water in the West." The authors are part of a joint program, also named Water in the West, of the Stanford Woods Institute for the Environment and the Bill Lane Center for the American West. The original article was written for Volume 6, Issue 1 of the California Journal of Politics and Policy, based at the Institute of Governmental Studies at the University of California, Berkeley, published in January 2014. The article is available in its entirety at http://waterinthewest.stanford.edu/sites/default/files/Final_WaterintheWest_CJPP.pdf.

1. Marc Reisner, *Cadillac Desert*: The American West and Its Disappearing Water (1986); Stewart L. Udall, *Beyond the Mythic West* (1990); Wallace Stegner, *The American West as Living Space* (1987).
2. The mandate of the Commission was to focus principally on the role of federal government in western water management for the next 20 years. We do not limit ourselves to that narrow focus here. Western Water Policy Review Advisory Commission, *Water in the West: Challenge for the Next Century* (1998).
3. The 1973 National Water Commission Report took 5 years and cost $22M, and the 1998 Report took 2 years and cost $2.5M.
4. Ross W. Gorte, Carol Hardy Vincent, Laura A. Hanson, and Marc R. Rosenblum, "Federal Land Ownership: Overview and Data," Congressional Research Service (2012). Niraj-Chokshi, "More Than Half of the West is Federally Owned. Now Some States Want That Land Back," Washington Post, October 15, 2013. Available at: http://www.washingtonpost.com/blogs/govbeat/wp/2013/10/15/almost-half-the-west-is-federally-owned-now-some-states-want-their-land-back/.
5. U.S. General Services Administration, Office of Governmentwide Policy, "Federal Real Property Profile, as of September 30, 2004," Table 16, pp. 18–19.

History of Water in the West

To understand the current trends affecting western water policy and management, it may be helpful to understand how we arrived here. Much of the current cultural and legal system of water allocation is a legacy of the 19th century while the infrastructure and institutions are products of the 20th century. A central question, of course, is how well this legal regime and infrastructure will fare in confronting the needs and issues of the 21st century.

In the East, through a common law system carried over from England and dating back to ancient Rome, property that abuts a water body carries with it a right to put that water to a reasonable use. This riparian system has worked well in areas with plentiful rainfall and a relatively consistent and abundant supply of water.[6] In the arid West, perennial streams are fewer and farther in between and their flows are variable and uncertain. The need to allocate a scarce and unpredictable resource gave rise to the prior appropriation system.

Emerging out of the western mining boom in the 1840s, this legal principle granted rights to water through a system of seniority that requires all users to put that water to beneficial use. Sometimes described as "first in time, first in right," the system allowed miners and later farmers and cities to divert water from its natural course provided they put that water to work. The initial water allocations were determined in the 19th century by who showed up first, dug irrigation ditches, and started withdrawing water. This system persists to this day, although now administrative and judicial programs in each state allocate new water rights and govern existing ones. Under this system, the rights of senior water users must be satisfied first, before junior users receive anything. Failure to put water to a beneficial use may jeopardize one's right to that water. This is sometimes described as "use it or lose it."

Most western states operate strictly under prior appropriation, although some treat groundwater separately.[7] Generally, holding a water right entitles an individual to use water for a specified beneficial use, which historically meant irrigation, mining, domestic, or municipal use. The terms of the water rights also typically include a priority date, an allowable quantity, and a specified location for the withdrawal.

A great deal of our infrastructure was also built up during the era of western settlement, as were the laws governing use of that infrastructure. John Wesley Powell, early explorer and scholar of the West, recognized early on that continued westward expansion by American settlers would require irrigation of the land. Powell advocated for a cooperative water development approach that was basin-oriented.[8] He wrote several seminal papers that warned about the folly of westward expansion without a fundamental shift in our thinking, institutions, and investments concerning water.[9]

Powell's words were largely ignored. The linear grids of the flatter East were superimposed on the more topographically and hydrologically complex West. It became increasingly clear that Powell was right about irrigation. So called "reclamation projects" were at first privately funded enterprises that time and again failed due to a lack of money, technical expertise, and organization. Resounding and persistent calls for the federal government to intervene eventually succeeded with passage of the Reclamation Act in 1902. The U.S. Bureau of Reclamation (BOR) under the Department of the Interior quickly studied potential water development projects in each western state, with the first projects funded by the sale of federal lands. This launched the federal government into a seven-decade era of dominance in large water developments throughout the West.

The Dust Bowl and the Great Depression, under Franklin Roosevelt, further intensified federal involvement in the West, as job creation became a driving rationale for large water development projects. These large projects enabled the mass settlement of the West in the 1940s. Although the Reclamation Act originally focused on providing infrastructure for irrigating family farms of 160 acres or less, water and power from reclamation projects ultimately facilitated large-scale agriculture and development of mega cities such as Las Vegas, Phoenix, and Los Angeles. State water projects, most notably in California, further added to the storage and plumbing infrastructure of the West. This expansion and growth helped set the stage for today's conflicts between agricultural and urban uses.

By the 1960s, increasing public consciousness of pervasive and widespread

6. Riparian states are not exempted from water scarcity, as shown in recent conflicts between Georgia, Florida, and Alabama. For a complete understanding of US water law, see Barton Thompson, Jr., John Leshy, and Robert Abrams, *Legal Control of Water Resources, Fifth Edition* (West Publishing, 2013).

7. Barton Thompson, Jr., John Leshy, and Robert Abrams, *Legal Control of Water Resources, Fifth Edition* (West Publishing, 2013).

8. For an overview, see National Public Radio, "The Vision of John Wesley Powell," August 26, 2003, available at: http://www.npr.org/programs/atc/features/2003/aug/water/part1.html.

9. John Wesley Powell, *Report on the Lands of the Arid Regions of the United States* (1878).

water pollution and ecological damage gave birth to the modern environmental movement. Several high-profile fights took place over dam construction in the West, as environmental advocates began to utilize new tools and employ more sophisticated strategies.[10] What soon followed was the passage of a raft of federal legislation including the Wild and Scenic Rivers Act (1968), National Environmental Policy Act (1970), Clean Water Act (1972), and Endangered Species Act (ESA) (1973). These federal laws recognized the importance of the environment and its connection to human health, and they fundamentally changed the way water projects (and any actions with a federal nexus) are planned and implemented.

By the 1980s, the development boom had run out of steam and the consequences of its excesses began to take hold. Due in large part to dams and water withdrawals, populations of Pacific salmon and other aquatic species began to crash. There are now about thirty fish that are federally listed as threatened or endangered in California alone.[11] Mandated restrictions on water withdrawals to protect fish provoked an inevitable backlash. Building on the backlash against restrictions on logging prompted by the spotted owl listing, and on private property rights movements such as the sagebrush rebellion, ranchers and other western water users have condemned environmental restrictions on water use as an attack on the rural way of life in the West.

Subsequent years were marked by political and legal battles between these two sides, mostly resulting in stalemate. While the 1990s and early 2000s saw some examples of collaboration and environmental restoration, there were no major laws passed or protections granted to waters and lands (nor were any repealed).

Some suggest that we have entered into an era of "The New West." It is hard to guess how this new era will define itself, and it is debatable whether drawing a distinction around an era provides any real value or clarity,[12] but it is certain that today's West is different from even 15 years ago from a demographic, cultural, economic, and environmental point of view.

We see a New West characterized by denser (and growing) urban population centers, rising ecological and recreational values of rivers and streams, and a growing awareness of water scarcity. The population of the West has grown by 13.8%, or 8.7 million people, from 2000 to 2010.[13] Four out of the top five fastest growing states in the US, ranked by percentage change in population (projected between 1995 and 2025) are in the West: California (56%), New Mexico (55%), Arizona (52%), and Nevada (51%).[14] There are many divides in this New West that continue to pull westerners further apart, such as cities/agriculture, coastal/inland, wealthy/poor. Cities have typically used 20% of total water available, while agriculture used 80%.[15] In light of growing populations, urban demand for water will only grow. At least some of this demand will be satisfied by water transfers from agriculture to cities, and many rural communities view the loss of this water as a threat to their economic viability and their culture. The need to leave water in rivers to restore threatened and endangered species only adds to the potential for conflict.

While conflict is a real issue in western water, it is not the whole story; there are signs of more resilient and cooperative approaches to water management in this new West. From southern California's shift to diversify its water supply with local and recycled sources, to climate change legislation on state and local levels, to a basin-wide study of the Colorado River to understand its current and future water demand and supply, efforts are being made at all levels to mitigate water and climate risks, often by working together. These are all promising signs that westerners are at the verge of creating a society to match its scenery, as Stegner had hoped for.

In this paper, we investigate some of the key issues that dominate today's conversations about western water and explore how some of these issues have

10. Daniel McCool, "River Republic: The Fall and Rise of America's Rivers" (Columbia University Press, 2012).

11. Department of Fish and Game, Natural Resources Agency, State of California, "State & Federally Listed Endangered & Threatened Animals of California," (2013). Available at: http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/TEAnimals.pdf.

12. Paul Robbins, Katharine Meehan, Hannah Gosnell, and Susan J. Gilbertz, "Writing the New West: A Critical Review," *Rural Sociology* 74, no. 3, (2009), 356–382. Richard White, *It's Your Misfortune and None of My Own: A New History of the American West*, (University of Oklahoma Press, 1991).

13. The West includes Alaska, Ariz., Calif., Colo., Hawaii, Idaho, Mont., Nev., N.M., Ore., Utah, Wash., and Wyo. Source: U.S. Census Bureau, Census 2010; Census 2000; 1990 Census. www.census.gov.

14. See Paul Campbell, "Population Projections: States, 1995–2025," U.S. Census Bureau (1997), http://www.census.gov/prod/2/pop/p25/p25-1131.pdf. Note that census projections from prior to 2010 should be considered cautiously as the impact of the 2008 recession on population movements in the West could be substantial.

15. This is consumptive water use, which is the water removed from supplies that is not returned to water sources. For crops, plant transpiration and evaporation from the soil and foliage drive consumptive use.

emerged or evolved since the last comprehensive review of western water in 1998. In particular, we focus on water management and governance and preparing for a changing climate.

Water Management and Governance

Because of its very nature, water has always been a difficult resource to manage.

How do you draw boundaries around something that has no clear beginning or end? How do you manage something that is constantly moving and changing? How do you regulate something that does not have a clear owner? The complexities of water laws, policies, institutions, and investments are a reflection of the resource itself.

Look at a map of the western US and it becomes clear that the straight lines that form so many borders among the 17 states west of the 100th meridian defy the lines that matter most—its rivers and watersheds. Those borders complicate management of water as much as anything. Perhaps more than any other question affecting water in the West, the challenge of management and governance continues to perplex and confound policy makers and water professionals.

The US operates on a system of cooperative federalism, with responsibility and jurisdiction for water resources distributed and nested among federal, state, and local levels of government.[16] Traditionally, federal government maintains some authority over water quality and flood control, the states have retained primacy over water supply, while local agencies administer many of these programs and provide basic services to customers, including water supply and sewage.

At every level, jurisdiction over water resources is divided among numerous entities with responsibility for various and often overlapping pieces of the larger puzzle—sanitation, water delivery, flood management, fish and wildlife, recreation.[17] Long lamented, this balkanization has more recently been embraced for its checks and balances.[18]

... the challenge of management and governance continues to perplex and confound policy makers and water professionals.

What further complicates overlapping jurisdictions is that water moves—problems upstream tends to magnify as one moves downstream. This is true of both water quality (e.g., pollution) and quantity (e.g., excessive withdrawals). Benefits and costs are easily misaligned. Upstream communities incur the costs of maintaining clean water while downstream communities enjoy the benefits.

Commissioners of the 1998 report on Water in the West highlighted management and governance as one of its key concerns. The commissioners supported several fundamental goals of management and governance that work from the bottom up and the top down: 1) Improve decision making by coordinating at the basin level; 2) Develop measurable objectives for basin management; 3) Improve efficiency of agency activities through integration of programs and budgets; 4) Expand technical and financial support of watershed projects; and 5) Support basin trusts to maximize financial resources. There are certainly examples in the intervening years of improvements in each of these areas, although effective management and governance in western water is as elusive today as it was in Powell's time.

Today's Water Management and Governance

The past 15 years have been particularly marked by conflict over water in the West's largest and most storied river basins. Of course, the complexity and conflict that defines basins like the Colorado, Columbia, Sacramento-San Joaquin, Rio Grande and Missouri should not come as any great surprise. These rivers involve tremendous historic competition between upstream and downstream jurisdictions, competing industries, and competing demands served by major federal infrastructure projects. With the exception of the Sacramento-San Joaquin, each of these rivers is governed by complex interstate and even international agreements. And each is home to a complex and fragile ecosystem with species that have become endangered because of water use and infrastructure.

Competition between upstream and downstream states on the Missouri River led to litigation over the operation of a series of dams in Montana and the Dakotas that brought into conflict navigation, flood control, power production, and

16. Andrea K. Gerlak, "Federalism and US Water Policy: Lessons for the Twenty-First Century," *The Journal of Federalism* 36 no. 2 (2005), 231–257.

17. In fact, there are estimated to be more than 52,000 community public water systems that are publicly owned, cooperatives, or privately owned that have a direct hand in some kind of traditional water management. See Environmental Protection Agency, "FACTOIDS: Drinking Water and Groundwater Statistics for 2009," Office of Water (2009). http://www.epa.gov/ogwdw/databases/pdfs/data_factoids_2009.pdf.

18. Martin Doyle, "American River Management," *Journal of the American Water Resources Association* 48, no. 4 (2012).

recreation as well as ecosystems protection.[19] While the litigation ostensibly centered on the fate of endangered fish and birds, the real dispute is on allocation of water between upstream and downstream states. Another focus of almost non-stop litigation has been the interaction between dams and salmon in the Columbia River basin, involving upstream and downstream states, tribes, environmental advocacy groups, and hydropower and navigation lobbies.[20] With billions of dollars spent in court and on mitigation, little has changed in the Columbia River basin.

One effort at a new governance structure that many believed showed promise at tackling large, interdisciplinary water management problems was the CALFED process. Established in 1994 as an effort to coordinate the efforts of state and federal agencies to maintain water supplies for cities and agriculture, improve water quality, and restore the Sacramento-San Joaquin Bay Delta ecosystem for endangered species, this 10-year cooperative effort culminated in a plan for coordination and action among 25 federal and state agency participants.[21] While these achievements were unprecedented and exhibited remarkable progress, many criticized the program for generating lots of process but yielding few results.[22] Since the demise of CALFED, additional efforts at coordination and collaboration have arisen to manage and govern the Delta, each with their own mixed result.[23] And of course, litigation remains a constant.

Given that it is the West's largest and most arid basin, it is ironic that the Colorado River arguably has seen greater degrees of cooperation and collaboration than others in the region. The cooperation could be driven by a pressing need: the basin is over-allocated, with less water than presumed in the Colorado River Compact.[24] In 2009, Congress passed the SECURE Water Act, which among other things directed the Bureau of Reclamation to conduct comprehensive studies to evaluate and define options for meeting future water demands in rivers basins in the West, including the Colorado.[25] While parties are still a long way from agreement about how to resolve long-term water needs and have not fully achieved interjurisdictional coordination of regulations, investments, and plans, they are certainly moving in a more positive direction than ever before.

It has been said in the financial world that there are institutions that are "too big to fail." Despite the many odds stacked against them, this may be an apt description of the major river systems of the western US. Perhaps this is why the largest and most contentious among them may be showing the greatest signs of cooperation. The Colorado Basin states have made progress working towards a solution to their severe problems because they have to—they face a genuine shortfall in the face of acute demand that they cannot fail to address.

So where do we go from here? If we are still discussing the same issues that Powell raised in the 1800s, it either suggests we need to press harder for more concrete action, or that we need to change the conversation.

The 1998 Report stressed the need for a coordinating body for water, particularly among federal agencies, and recommended reconvening the Water Resources Council (1965–1981). While it has not been convened or funded since 1981, the Council remains authorized by law and was originally empanelled

19. South Dakota v. Ubbelohde, 330 F.3d 1014, 1020 (8th Cir. 2003); In re: Operation of the Missouri River System Litigation, No. 07-1149 (8th Cir. Feb. 8, 2008) (affirming lower court, upholding U.S. Army Corps operations along Missouri River.); for more information, see Karla Hauk: "Missouri River Case: A River Runs Through it, in re: Operation of the Missouri River System Litigation," *Great Plains Nat. Resources Journal* 61 (2005).

20. Michael Blumm, "The Real Story Behind the Columbia Basin Salmon Debacle: Dam Preservation under the Endangered Species Act," *Environmental Law* 41, Lewis & Clark Law School Legal Studies Research Paper No. 2011-16, July 12, 2011; see also The Oregonian, "Timeline, major players in the Northwest salmon lawsuit in the Columbia River basin," May 07, 2011. http://www.oregonlive.com/environment/index.ssf/2011/05/timeline_major_players_in_the.html.

21. CALFED Bay-Delta Program Archived Website, "Record of Decision and other Key Documents," http://calwater.ca.gov/calfed/library/Archive_ROD.html.

22. CALFED Bay-Delta Program Archived Website, "History of CALFED Bay-Delta Program," http://www.calwater.ca.gov/calfed/about/History/Detailed.html.

23. See the Bay Delta Stewardship Council http://deltacouncil.ca.gov/, and the Bay Delta Conservation Partnership http://baydeltaconservationplan.com/Home.aspx. For a comprehensive examination, see National Research Council, *Sustainable Water and Environmental Management in the California Bay-Delta* (Washington, D.C., The National Academies Press, 2012). http://www.nap.edu/catalog.php?record_id=13394.

24. U.S. Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study," 2012.

25. For a summary, see Bureau of Reclamation, "The Water Conservation Initiative and Implementation of the Secure Water Act," available here: http://www.usbr.gov/lc/region/programs/crbstudy/SWA.pdf.

to coordinate the planning, investments, management, and regulation of water resources among federal agencies.[26] It also included provision for better coordinating federal activities with states, local agencies, and the private sector. Although President Obama has not heeded calls to reconstitute the Council, his Administration has convened an ad hoc interagency task force around water resource issues.[27] While it is difficult to see whether those efforts have translated to actions on the ground, they appear to be responding to this commonly cited need for federal coordination.

A major theme dominating current discussions about water management and governance is the concept of integrated water resource management (IWRM). Integrated management is commonly thought of as coordinated planning, comanagement of water quantity, quality, flood control, land use, and ecosystems, and sharing information across disciplines and agencies. Proponents say benefits include more efficient and cost effective management, reliable water supplies, adaptability in the face of climate change, and equity across sectors.

Integrated water management has a particular resonance among western water managers given the interrelation of the resources they are entrusted with and the complexity of the institutions and legal structures they must navigate. For example, operating a reservoir requires balancing between storing as much water for consumptive use as possible, while leaving storage space available in the event of a flood. Water left instream may be beneficial to both wildlife and hydropower, but can place strains on irrigated agriculture and cities. Land use decisions affect flood control, water demand, and the health of freshwater ecosystems, but are often made by government entities that have no experience or responsibility for these resources. Integrating the management of groundwater and surface water, which were once treated as separate resources in most western states, has become the norm in recognition of their hydrologic connection and because of its importance in providing cheap, reliable water storage.[28]

Perhaps the most tangible attempt to realize this vision of integration is California's Integrated Regional Water Management Planning program (IRWMP).[29] The program, administered by the Department of Water Resources and the State Water Resources Control Board, has been used to bring together the dozens of water agencies and stakeholders in hydrologic regions throughout the state to coordinate plans and prioritize water projects and investments to meet a wide array of regional objectives. The program uses access to state bond funding as an incentive for participation. Unfortunately, the prospect of continued water bond funding in California is unclear and it is uncertain whether this incentive is actually affecting the state's most difficult water management challenges.

There is really no beginning or end to the conversation about water management and governance in the western US, but based on trends, we expect that ever pressing needs will keep the discussion alive for years to come. Effective governance is necessary for functioning markets that not only improve economic efficiency but avoid impacts to rural communities and the environment. With climate change, the agreements struck between the states over the past several decades will almost inevitably need to be revisited, whether amicably or through the courts. And the need and desire to replace aging infrastructure, possibly with new technologies, will present opportunities for cooperative financing, coordinated management, and new governing regulations. Over the past 15 years, we have made some progress in better integrating water management decisions, but have not found ways to employ these lessons more broadly, or apply them to the region's most important water management problems.

Preparing for a Changing Climate

It is safe to say that almost every report, article, or document written about western water now devotes at least some of its attention to the present and future challenges of a changing climate. Given this overwhelming level of attention, it is startling to think that just 15 years ago, it was little more than a footnote.

In the past 15 years, confidence of climate change models and predictions have improved by leaps and bounds, and our understanding of current and future impacts is much clearer.[30] That in-

26. 18 CFR Chapter VI – Water Resources Council.

27. The Water Resources Development Act of 2007 directed federal agencies to rewrite the Principles and Guidelines for Water Resource Development Projects, which governs water infrastructure evaluation and decision-making among several federal agencies.

28. One notable exception is California where regulation and management of surface water and groundwater remain separate and distinct. See Barbara Tellman, "Why has Integrated Management Succeeded in Some States but not in Others?" *Journal of Contemporary Water Research and Education* (2011).

29. Department of Water Resources, State of California." Integrated Regional Water Management Grants" http://www.water.ca.gov/irwm/grants/index.cfm. Similar state efforts are underway in Oregon and Colorado.

30. Intergovernmental Panel on Climate Change (IPCC), "Climate Change 2013: The Physical Science Basis," http://www.ipcc.ch/report/ar5/wg1/#.UmlyWaWo4pE.

creased understanding has underscored the risks for western water supplies, and solidified.[31] Climate change has come to dominate the attention of the water sector in the West.

The climate of the West has always been characterized by extreme variability. The region has seen some incredible extremes and the so-called "normal" water year is ever elusive. Tree rings and other paleoclimatic data present a picture of the climate of western North America frequented by droughts and punctuated by catastrophic floods. Numerous droughts, greater than any witnessed by European settlers, plagued the Colorado River basin between 750 and 1500.[32] At the other end of the spectrum, recent studies in the Central Valley of California show a regular incidence of "biblical" floods that filled the Central Valley every 200 years.[33] The region is no stranger to climatic extremes, but all of the models of climate change predict with a great degree of confidence that those extremes will become even greater and more frequent because of greenhouse gas pollution.

A growing body of research and reports, such as the 2009 National Climate Assessment[34] and a 2011 report to Congress from the Bureau of Reclamation,[35] point to significant threats to water resources from climate change. These can be summarized by the following:

- Average temperatures are rising, thereby increasing evaporation and increasing the severity of recent droughts;
- A greater portion of winter precipitation is falling as rain in the mountains rather than snow, and snow is also melting earlier in the year, compromising reliance on surface water storage in the West;
- Across the West warming, drought, and resulting insects and disease, will increase wildfires and impacts to people and ecosystems;
- Extreme rainfall events are expected to increase in frequency and intensity;
- Coastal flooding and erosion is already occurring and is damaging some areas of the California coast during storms and extreme high tides;
- Wildlife adapted to historic temperature regimes and hydrology are vulnerable to changing conditions.

The West has witnessed a number of extreme weather events over the past 15 years, although none can be attributed specifically to climate change.[36] Nevertheless, because these droughts and floods resemble the kinds of events forecast in various climate change scenarios, they have left an impression on both water managers as well as the general public.

A landmark paper by Miley et al. (2008) in Science, entitled, "Stationarity is Dead," lays out the idea that the past is no longer a sufficient predictor of the future and that we need to adjust the way we plan for our water resources in the future. That presents a tremendous challenge. The West's dams, levees, and other infrastructure, once the envy of the water world, were built on past assumptions. Laws and policies on water rights, species recovery plans, and clean water permits are calibrated to data collected over the last century, for the most part. Land use decisions are dependent on that data and history as well. The realization that the future will not conform to the past is now leading to a transformation in the water industry and a whole new way of thinking and working.[37]

Despite the consensus within the scientific community around anthropogenic climate change and its impacts on water resources in the West, public attitudes in the region have been decidedly mixed. Regardless of politics and views about the causes of climate change, water managers seem to be heeding the risks and orienting their planning to address it—even if they may call it by another name.

Federal, state and local water agencies have undertaken significant planning efforts to ensure that the West's water resources and communities are

31. Ibid.

32. David M. Meko, Connie A. Woodhouse, Christopher A. Baisan, Troy Knight, Jeffrey J. Lukas, Malcolm K. Hughes, and Matthew W. Salzer, "Medieval Drought in the Upper Colorado River Basin," *Geophysical Research Letters* 34 (2007).

33. B. Lynn Ingram, "California Megaflood: Lessons from a Forgotten Catastrophe," *Scientific American*, (January 19, 2013).

34. U.S. Global Change Research Program, "Global Climate Change Impacts in the United States: 2009 Report," http://nca2009.globalchange.gov/water-resources.

35. Department of the Interior, "SECURE Water Act–Reclamation Climate Change and Water 2011," U.S. Bureau of Reclamation. http://www.usbr.gov/climate/SECURE/.

36. Examples include flooding in California in 1997, Missouri River floods in 2010, drought in Texas and the Plains in the 2000s, drought in California 2008–2011, and drought in the Colorado River basin from 2000 to present. While Hurricane Katrina and Superstorm Sandy did not occur in the Western states, they had significant impacts on public perceptions of risk around weather events.

37. L.D. Brekke, J.E. Kiang, J.R. Olsen, R.S. Pulwarty, D.A. Raff, D.P. Turnipseed, R.S. Webb, and K.D. White, "Climate Change and Water Resources Management: A Federal Perspective," *U.S. Geological Survey Circular* 1331, (2009), 65. http://pubs.usgs.gov/circ/1331/.

prepared for a changing climate. Beginning in 2009, federal agencies began working with stakeholders to develop a National Action Plan that provides an overview of the challenges a changing climate presents for the management of the nation's freshwater resources and describes actions that federal agencies will take to help freshwater resource managers ensure adequate water supplies and protect water quality and public health.[38] In February 2013, federal agencies released their first Climate Change Adaptation Plans to plan for and address the impacts of climate change on their programs and operations. As part of a new partnership among the National Oceanic and Atmospheric Administration and universities throughout the nation,[39] the Western Water Assessment was established at the University of Colorado, Boulder to evaluate and address societal vulnerabilities related to climate change and water resources and provide advice and direction to local decision-makers about how best to prepare.[40]

Federal agencies are not alone in their efforts to confront the challenges of a more volatile and uncertain climate. Over the past several years, the Western Governors' Association (WGA) has issued several reports describing vulnerability of states to a changing climate, as well as serving as a clearinghouse to share advice and best practices among them.[41] WGA's 2010 climate adaptation report emphasizes the need for states to coordinate with federal agencies on good science and best practices.

The front lines of water management remain at the local level—municipalities, counties, and utilities, as well as businesses and individuals. Numerous communities throughout the West such as Seattle, Boulder, and the state of California, have been identified as models of adaptation planning for the rest of the world.[42] Colorado and other states have modified drought mitigation and response plans to consider the impact of climate change. There have been a number of excellent publications that provide direction and guidance to planners in developing adaptation plans.[43] Adaptation planning has turned out to be a natural integrator of more traditional water management plans that until now were developed and functioned independently. Planners for land and water are finding opportunities to collaborate and pool resources around the need to plan for climate change.

There are certainly numerous jurisdictions that have yet to pick up this mantle but even water agencies in conservative parts of the region are finding ways to address the risks of climate volatility without wading into debates over the causes. The state of Oklahoma has an exceptional state water plan that gives careful consideration to a changing climate.[44] In early 2013, the Idaho legislature passed a state water plan despite its references to climate change and variability.[45]

Many best practices, legal reforms, and investment decisions that are recommended in the face of a changing climate are little more than restatements of past recommendations for sustainable water management. Nevertheless, the addition of climate change to the historic list of threats to western water management appears to be creating a new sense of urgency to implement old and new solutions.

---

38. Interagency Climate Change Adaptation Task Force, "National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate," (2011). http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_national_action_plan.pdf.

39. NOAA's Regional Integrated Sciences and Assessments (RISA) Program is a collaboration of 11 regional programs operating across the U.S.

40. Information about the Western Water Assessment is available at http://wwa.colorado.edu.

41. Western Governor's Association's work on climate change can be found here: http://www.westgov.org/initiatives/climate.

42. See http://www.georgetownclimate.org/adaptation/state-and-local-plans?order=province&sort=desc and https://bouldercolorado.gov/pages/climate-adaptation; California has the first statewide climate adaptation program in the U.S. See California Natural Resources Agency, "2009 California Climate Adaptation Strategy: A Report to the Governor of the State of California in Response to Executive Order S-13-2008," State of California, (2009).

43. Ben Chou, "Ready or Not: An Evaluation of State Climate and Water Preparedness Planning," *Natural Resources Defense Council Issue Brief*, (April 2013). Fay Augustyn and Ben Chou, "Getting Climate Smart: A Water Preparedness Guide for State Action," *American Rivers and Natural Resources Defense Council* (2013).

44. Oklahoma Water Resources Board, "2012 Oklahoma Comprehensive Water Plan Update," (2011). Available at: http://www.owrb.ok.gov/supply/ocwp/ocwp.php.

45. Idaho Water Resource Board, "State Water Plan," (2012). The document is available here: http://www.idwr.idaho.gov/waterboard/WaterPlanning/Statewaterplanning/State_Planning.htm.

News (FROM PAGE 5)

Left-Right: Roger Gorke (U.S. Environmental Protection Agency), Bob Vallario (U.S. Department of Energy), Steven Nadel (American Council for an Energy-Efficient Economy)

Bob Vallario, Program Manager for Integrated Assessment of Global Climate Change in the U.S. Department of Energy Office of Science, began the discussion with an overview of the energy-water nexus. Vallario discussed the role of the Department of Energy in addressing the nexus through its technology, data, modeling and analysis capabilities. The agency aims to leverage strategic interagency connections to analyze and respond to interconnected energy and water needs, while engaging stakeholders as part of a cohesive response framework.

Steven Nadel, Executive Director of the American Council for an Energy-Efficient Economy, discussed policy options to conserve both energy and water and increase their efficiency of use. These included encouraging end-users to undertake assessments and actions, promoting energy efficiency at water facilities and water efficiency at energy facilities, equipment efficiency standards, building codes, joint energy-water programs, decoupling, and EPA's Clean Power Plan. He encouraged the inclusion of water within current energy-saving programs, as well as the energy resource planning process.

Roger Gorke, Senior Policy Advisor for the U.S. Environmental Protection Agency Office of Water, examined the ongoing California drought in the context of the energy-water nexus. He discussed several federal, state and regional initiatives to respond to the drought and encourage resilience, as well as the need for improved water management policies. Gorke noted that the energy-water nexus is particularly important in this region: California requires approximately four times as much energy to pump, treat, and use water compared to the national average. He stated that managing water resources on a broader, macro-scale would improve water conservation, as well as reduce energy demand.

American Geophysical Union

Leading Scientists Gather for Conference on California Drought

California is in its fourth year of drought, affecting the holders of more than 36,000 water rights that serve 30 million people and irrigate over 5,680,000 acres of farmland. Following the lowest snowpack ever recorded in the state and with no end in sight, Gov. Edmund G. Brown Jr. on April 1, 2015 ordered cities and towns across California to cut water use by 25 percent – a first in state history.

At AGU's Chapman Conference on California Drought from April 20-22, 2015, national researchers and state water managers explored drought monitoring and prediction, sought to better understand the drought's impacts on the water supply and ecosystems, discussed possible links to climate change, and identified policy and management solutions to enhance California's resilience. The conference aimed to highlight key research gaps and produce a road map for future work.

For more information, contact AGU, 2000 Florida Ave NW, Washington, DC 20009; (202) 462-6900, www.agu.org.

American Meteorological Society

AMS Washington Forum: Unleashing Big Data and Big Discussion

At her April 21, 2015 keynote address to the AMS Washington Forum, U.S. Secretary of Commerce Penny Pritzk-

er announced that NOAA is forming five new alliances to help bring its vast data resources to the public. The partnerships with Amazon Web Services, Microsoft Azure, IBM, Google, and the Open Cloud Consortium address the growing need for access to NOAA's huge—and rapidly growing—environmental data resource.

NOAA issued a Request for Information (RFI) in February 2014 to see who might be able to help move NOAA data onto the cloud. Commercial partnerships would, according to the RFI, help pull together disparate NOAA sources and web sites and help people "find and integrate data from these sources for cross-domain analysis and decision-making."

NOAA Administrator Kathryn Sullivan elaborated on the scope of the Big Data need:

"Of the 20 terabytes of data NOAA gathers each day—twice the data of the entire printed collection of the United States Library of Congress—only a small percentage is easily accessible to the public."

The cloud was a way to alleviate this situation, as the RFI stated:

"NOAA anticipates these partnerships will have the ability to rapidly scale and surge; thus, removing government infrastructure as a bottleneck to the pace of American innovation and enabling new value-added services and unimaginable integration into our daily lives."

For more information, contact AMS, 45 Beacon Street, Boston, MA 02108; (617) 227-2425, www.ametsoc.org.

American Society of Civil Engineers

ASCE Members Meet With US Lawmakers

As part of ASCE's 15th annual Legislative Fly-In from March 24-26, 2015, nearly 200 ASCE members descended on the nation's capital to encourage members of Congress to fix the Highway Trust Fund.

The event included briefings on federal legislative issues, including the Water Resources Reform and Development Act (WRRDA) appropriation process and the need for Congress to pass a long-term transportation bill this year. To further the conversation on transportation, attendees were addressed by the U.S. Department of Transportation Under Secretary for Policy, Peter Rogoff, on Tuesday evening and Congressman Earl Blumenauer (D-OR) on Wednesday morning.

The 200 ASCE members in attendance then headed to Capitol Hill to meet with members of Congress and their staffs of 46 states and the District of Columbia.

During the proceedings, Sen. Barbara Boxer (D-CA) and Rep. Bill Shuster (R-PA) were both presented with awards naming them Honorary Fellows of the Society.

For more information, contact ASCE, 1801 Alexander Bell Drive, Reston, VA 20191; (800) 548-2723, www.asce.org.

American Society of Landscape Architects

Registration Opens for 2015 ASLA Annual Meeting & Expo in Chicago

The American Society of Landscape Architects (ASLA) has opened registration for its 2015 Annual Meeting & EXPO, to be held November 6-9 in Chicago at McCormick Place. ASLA's annual meeting is the largest gathering of landscape architecture professionals and students in the world.

The 2015 meeting, themed "Perspectives," highlights the comprehensive viewpoint that helps enable landscape architects to effectively solve today's complex planning and environmental design problems.

More than 6,000 attendees are expected, and the meeting will feature a diverse spectrum of industry experts providing perspectives on a wide range of subjects, from sustainable design to active living to best practices and new technologies. More than 130 education sessions and field sessions will be presented during the meeting, providing attendees with the opportunity to earn up to 21 professional development hours under the Landscape Architecture Continuing Education System™ (LA CES™). Many of the sessions will also qualify for continuing education credit with the Green Building Certification Institute (toward LEED AP credential maintenance), the American Institute of Architects, the American Institute of Certified Planners, and other allied professional organizations and state registration boards.

For more information, contact ASLA, 636 Eye Street NW, Washington, DC 20001; (202) 898-2444, www.asla.org.

American Water Resources Association

AWRA 2015 Annual Conference

The mile-high city of Denver, Colorado will host the AWRA Annual Conference in 2015. Scheduled for November 16-19, the conference will be held in downtown Denver at the Grand Hyatt Hotel Denver. Join AWRA for an engaging week of cutting edge presentations on timely water resources issues, and for dialogue from fellow water resource movers and shakers from across the country and throughout the world. The conference will host a diverse group of water resources professionals who will present their latest research and case studies, discuss current hot topics, and share new ideas.

Super Saver registration for the conference ends September 4, 2015.

For more information, contact AWRA, P.O. Box 1626, Middleburg, VA 20118; (540) 687-8390, www.awra.org.

Geological Society of America

GSA Completes Archive Project

The Geological Society of America has completed a major publications digitization project that includes books, maps, and journal content published by the Society since 1890. More than 865 e-books and 187 years of journal content are now available through a variety of locations, including the Society's Web site at www.gsapubs.org, the Society's online storefront at http://rock.geosociety.org/store/, GeoScienceWorld, Geofacets, Amazon, iBooks, and Google Play.

"This represents a major milestone in our pursuit to make more geoscience research available," said GSA Publications Committee Chair Jennifer A. Thomson. "Usage has shown that this research remains valuable long after it was originally published. Making this content accessible honors the time and effort of these authors and ensures that their work will be widely used well into the future."

For more information, contact GSA, P.O. Box 9140, Boulder, CO 80301; (303) 357-1806, www.geosociety.org.

Society of Environmental Toxicology and Chemistry

Nominations being accepted for 2016 SETAC Rachel Carson Award

This prestigious award is only given every four years. The application deadline is 15 July 2015, and the award will be presented during the 7th SETAC World Congress/SETAC North America 37th Annual Meeting in Orlando, Florida in 2016. Membership of SETAC is not a prerequisite for this award, and self-nominations are welcome.

Please submit an award application if you know of an individual or a group that has:

- A desire to help others understand and become more aware of the natural world and appreciate the potential threats that anthropogenic stressors may have on the integrity and functioning of that world
- A demand for accuracy in assembling and using scientific facts to present, support and ultimately defend writings or other forms of communication
- A broad view of environmental issues that includes habitat and physical impacts as well as chemicals
- A recognition for the need for education
- A desire to make science more accessible to the public
- A voice for political change, even in the face of controversy

For more information, contact SETAC, 229 S. Baylen Street, Pensacola, FL 32502; (850) 469-1500, www.setac.org.

Society of Wood Science & Technology

World Wood Day Events focus on the Odunpazarı District of Eskişehir, Turkey, March 6-31, 2015

Though World Wood Day is celebrated on March 21st each year, the official events began on March 6th with a 2½ week international, collaborative timber "bridge" project and ended in Istanbul March 31 with a special 4-day program related to wooden architecture and timber construction in the Şişli District of Istanbul. About 380 people from 93 countries participated in presenting this major event with excellent support from the District of Odunpazarı (which translates to "wood market" in English).

Booths and tents were set up so that the hundreds of people of all ages from the general public and other could view and learn from woodcarvers, wood turners, furniture makers, folk arts workshops. Events also included demonstrations and performances of various wooden musical instruments. A technical symposium with 31 speakers ran over two days under the heading of Wood and Humanity: An Interdisciplinary Approach to Sustainable Development. The topics focused on raising awareness of current issues and enhancing multidisciplinary discussions for the crucial role of wood in human civilization and the environment. The day after WWD, many of the attendees traveled to a local community park area to plant black pine tree saplings to emphasize the need for a sustainable source of trees for both beauty and products.

More details and pictures from these meetings and tours can be found at the World Wood Day 2015 websites http://www.worldwoodday.org/2015/ and https://www.facebook.com/worldwoodday.

For more information, contact SWST, P.O. Box 6155, Monona, WI 53716; (608) 577-1342, www.swst.org.

Meetings

See http://www.rnrf.org for additional meetings

Submit Meeting Notices to: info@rnrf.org

June 2015

Harvest the Future International Symposium. June 14-17, 2015. Montego Bay, Jamaica. http://www.harvestthefuture.org/

American Geophysical Union Chapman Conference. Evolution of the Asian Monsoon and its Impact on Landscape, Environment and Society: Using the Past as the Key to the Future. June 14-19, 2015. Hong Kong SAR, China. http://chapman.agu.org/monsoon/

2015 Energy Information Administration Energy Conference. June 15-16, 2015. Washington, D.C. http://www.fbcinc.com/e/eia/

American Water Resources Association Summer Specialty Conference on Climate Change Adaptation. June 15-17, 2015. New Orleans, LA. http://www.awra.org/meetings/NewOrleans2015/

2015 UCOWR/NIWR/CUASHI Conference, Water is Not for Gambling: Utilizing Science to Reduce Uncertainty. June 16-18, 2015. Las Vegas, NV. http://ucowr.org/conferences

Air & Waste Management Association 108th Annual Conference & Exhibition. Connecting the Dots—Environmental Quality to Climate. June 22-25, 2015. Raleigh, NC. http://www.awma.org/conferences/conferences-detail-view/2015-annual-conference-and-exhibition

36th IAHR World Congress—Deltas of the Future. June 28-July 3, 2015. Delft—The Hague, the Netherlands. http://www.iahr2015.info/

American Meteorological Society, 27th Conference on Weather Analysis and Forecasting. June 29-July 3, 2015. Chicago, IL. http://www.ametsoc.org/MEET/fainst/201527waf.html

July 2015

International Scientific Conference, "Our Common Future under Climate Change." July 7-10, 2015. Paris, France. http://www.commonfutureparis2015.org/

National Association of Clean Water Agencies Summer Conference. July 12-15, 2015. Providence, RI.

National Environmental Health Association Annual Educational Conference & Exhibition. July 13-15, 2015. Orlando, FL. http://neha2015aec.org/

Annual Green Chemistry & Engineering Conference. July 14-16, 2015. North Bethesda, MD. http://www.gcande.org/

American Society of Agricultural and Biological Engineers 2015 Annual International Meeting. July 26-29, 2015. New Orleans, LA. http://www.asabemeetings.org/

Soil and Water Conservation Society Annual Conference. Coming Home to Conservation: Putting Science into Practice. July 26-29, 2015. Greensboro, NC. http://www.swcs.org/en/conferences/2015_annual_conference/

American Geophysical Union, Chapman Conference on the Width of the Tropics: Climate Variations and Their Impacts. July 27-31, 2015. Santa Fe, New Mexico. http://chapman.agu.org/tropics/

August 2015

International Congress for Conservation Biology. August 2-6, 2015. Montpelier, France. http://www.iccb-eccb2015.org/

American Society of Civil Engineers, EWRI Watershed Management Conference. August 5-7, 2015. Wenatchee, WA. http://www.watershedmanagementconference.org/

Ecological Society of America 2015 Annual Meeting. August 9-14, 2015. Baltimore, MD. http://esa.org/baltimore/

American Fisheries Society Annual Conference. August 15-20, 2015. Portland, OR. http://2015.fisheries.org/

Renewable Resources Journal
Renewable Natural Resources Foundation
6010 Executive Blvd., 5th Floor
North Bethesda, Maryland 20852-3827 USA
Change Service Requested

First Class Mail
U.S. Postage
PAID
Hanover, PA 17331
Permit No.4

Printed on recycled paper

Printed with vegetable-based ink