
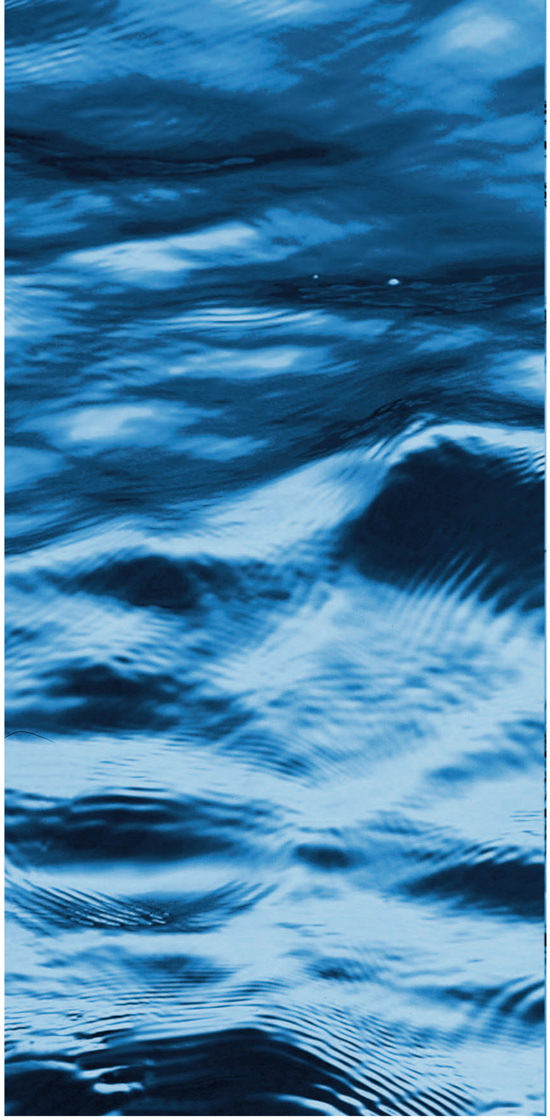


ENERGY, WATER, AND DEBT:

Linked Problems, Common Solutions?

HUDSON INSTITUTE

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Edited by Lee Lane

Based on a conference held at Hudson Institute, Washington, DC, January 12, 2012

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Introduction

A conference entitled "Energy, Water, and Debt: Linked Problems, Common Solutions?" was held on January 12, 2012, at Hudson Institute's Betsy and Walter Stern Conference Center in Washington, DC. In his opening remarks, Hudson President and CEO Kenneth R. Weinstein thanked Grundfos North America for graciously underwriting the conference, while leaving Hudson Institute in full control of the format, content, and selection of speakers. Following is a summary essay by Hudson Institute Visiting Fellow Lee Lane, who moderated the first panel. Also included in this report is an edited transcript of the keynote speech as well as two panel discussions with Q&A.

The participants included:

- Jim Nussle, President and COO, Growth Energy (keynote speaker)
- Craig Zamuda, Senior Policy Adviser, Office of Climate Change Policy and Technology, Department of Energy
- John Lyman, Director, Energy and Environment Program, The Atlantic Council
- W. David Montgomery, Senior Vice President, NERA Economic Consulting
- Gary Libecap, Professor of Corporate Environmental Management, Bren School of Environmental Science and Management, University of California Santa Barbara
- Jes Munk Hansen, President, Grundfos North America
- Sheila Olmstead, Fellow, Resources for the Future
- Kassia Yanosek, Founding Principal, Tana Energy Capital LLC

A Framework for Policy Analysis

Summary Essay by Lee Lane, Hudson Institute Visiting Fellow

The conference sought to explore issues central to the links between water and energy. It did not intend either to solve those problems or to produce consensus. It did not do so. It did, however, map out several options for grappling with the water energy problem.

The most appealing means of dealing with water and energy problems centers on institutional reform. Many options surfaced during the event. Some of them relate to improving the policy process. These concepts encompass better data and models, as well as more attention from both the public and policymakers.

Several speakers also called for a more coherent policy. Still, the United States, except in times of crisis, finds such coherence to be a challenge. Separation of powers, federalism, and the entrenched power of "permanent Washington" are core features of the U.S. system of governance. Together they create strong barriers to policy coherence. It is hard to see much ground for hope that the water-energy nexus will escape the tug of the prevailing centrifugal forces.

In principle, reforms that would lead to better water pricing have much greater appeal. The reform of water rights in the American West seems to offer particularly far-reaching benefits. Progress on this subject could go a long way toward meeting urban and energy-sector water shortages. Better still, it could do so with only modest new investments in infrastructure. Nor would this approach require daring leaps into untried technologies.

Pricing urban water systems to reflect scarcity also seems to carry promise. Such a policy would lessen the demand for new system investments. It might also augment revenues on hand for building those assets that were truly needed. Such savings are all the more important in a time of prolonged fiscal dearth and slow economic growth.

In the same vein, some discussants argued that repealing many current energy mandates and subsidies would lower the costs and enhance the supply of both energy and water. Whatever the new renewable fuels program's (RFS2's) other merits, it raises fuel costs and boosts the demands on major, already stressed aquifers. Other renewable and conservation policies may also raise the costs of the total energy system. Some of these programs hope to promote the energy sources of the future. To some participants, though, they are merely maintaining so many hothouse plants. The technologies that they support cannot pass a market test. Nor do they have any obvious prospect of evolving into something that could.

Attractive as these institutional reform policies are, the gains from them may be hard to capture. Property rights for western water are poorly defined in large measure because defining property rights is costly; so is changing them. Hopes to price urban water systems more realistically collide head on with the incentives of office holders. That is, the office holders have reasons to hide the costs of their policy choices from the voters who elect them. Subsidies and mandates for noncompetitive technologies are a common feature of government. They prevail so widely because they create economic rents, and those in government can capture some of those rents.

If institutional reform is difficult, should technology mandates attempt to fill the policy vacuum? Or, at the least, should government act to promote labeling and education? Some speakers think so. Without doubt, energy and water use incur external costs. Using less of them, though not free, would presumably lower these costs. Consumers in the water industry lack the knowledge needed to make rational economic decisions.

Yet technology mandates are a perilous option. Energy Independence and Security Act of 2007 (EISA) regulations do not require benefit-cost tests, and some of the act's current mandates might well fail such a test. A standard that raises energy efficiency may well cost society more than the value of the savings it achieves. Hence, adding new standards could result in net costs rather than net gains. It is certain that a case-by-case pricing of specific external costs would solve these problems at lower costs than could a broad-brush attack on energy use.

In sum, all of the proposed policy prescriptions should be viewed in light of the teachings of Nobel laureate Ronald Coase. Presence of a market failure does not per se warrant government action. True, markets are often imperfect. At the same time, parochialism and myopia are endemic in the policy process. Thus, in all policy issues of this type, the threshold issue is a comparison: if government acts, which value will be greater, the fall in harm from the market failure, or the new costs that will spring from a policy that, inevitably, will be flawed?

Keynote Speech

Energy, Water, and Debt: Linked Problems, Common Solutions?

by
Jim Nussle,
President and COO, Growth Energy

Welcome:
Kenneth Weinstein,
President and CEO, Hudson Institute

The following is an edited transcript.

KENNETH WEINSTEIN: Good afternoon and welcome to the Walter and Betsy Stern Conference Center here at Hudson Institute for today's event to discuss the confluence of water, energy and debt. I'm Kenneth Weinstein, President and CEO of Hudson Institute.

Last year, Hudson celebrated a half century of forward-looking analytic policy research. Herman Kahn and Max Singer founded Hudson in 1961 because they saw the need for a more publicly engaged policy research organization that would think creatively about how to achieve a better future, particularly through the creative use of innovative technology and an encouraging policy environment. They created an Institute that would draw on creativity to help shape the public debate on the critical issues of the day.

Today's event is a particularly noteworthy heir to that legacy. Current trends are making the critical links between energy and water even more important. With continued economic uncertainty wreaking havoc on local budgets, high and rising public debt is making it far less plausible that public funding will be able to cover the rising costs associated with energy and water scarcity.

These issues are, of course, closely linked. Energy accounts for up to eighty percent of the cost of water. As a result, energy price trends are a key factor in shaping water supply and water cost. Conversely, water is a key input to energy supply, which itself is significantly evolving, as we'll hear from our keynote speaker this morning. Quite simply, the discussion today is highly necessary and highly relevant.

In the interest of full disclosure, I should note that today's panels are being sponsored by Grundfos, which is the world's largest manufacturer of water pumps. We are grateful to Grundfos for their support of today's event. Hudson Institute maintains complete intellectual control of the discussion. We're here to raise issues and to discuss them and we appreciate Grundfos for allowing us to have an open and fair discussion on these issues in the manner in which we chose to do it.

As we begin our examination today, I can think of no better way to begin than by a keynote from a man who brings a unique perspective to these issues, Jim Nussle, who has a long-term interest in agriculture, water, biofuels, and budget issues.

Jim Nussle served sixteen years in the U.S. House of Representatives, representing the First District of Iowa, and for six years chaired the House Budget Committee. He also served with great distinction as the thirty-sixth director of the Office of Management and Budget as a member of the Cabinet in the George W. Bush administration.

Today, he serves as Chief Operating Officer and president of Growth Energy, which is the fastest-growing trade association in the renewable energy field representing biofuel producers. It is my honor to turn the platform over to Jim, and we look forward to hearing from him.

JIM NUSSLE: Ken, thank you. When I woke up this morning I turned off my electric alarm clock. I reset my house alarm now that just about everybody has. I turned on the bathroom lights. I, of course, flushed the toilet. Took a glass of water and brushed my teeth. I took a nice long hot shower, shaved, dressed in my nicely-heated home. (I am going somewhere with all of this.) Cooked on our gas stove. Then, I made the toast in our electric toaster and washed the dishes in our dishwasher. Drove my car together with Karen.

We stopped for a tank of gas. Ten percent of it was ethanol—just a little commercial message there for you—and realized when I got to the office that I needed to start putting the finishing touches on the outline for my speech. These are all of the different experiences I had had just in those two hours with energy and water and the nexus between them, and I didn't even name all of them. But one thing is for certain. I took them all for granted. I didn't think about them once during that period of time, and if it wasn't for the fact that I had to write a keynote speech today, I probably wouldn't have thought about them again.

Let me start by saying thank you to Ken and to the Hudson Institute for inviting me to speak.

But it's a daunting task to take on these issues. First, I agree with Ken's comments that these two particular issues today of water and energy policy may very well be the defining issues of the twenty-first century. In many ways, shapes, and forms they will affect all of us as individuals, human beings, Americans, and members of the planet Earth.

Policy developments may come through a very calm, sober, deliberative policymaking process or, sadly and growing more likely every day, they may occur as a result of shortages, conflicts, strife, possibly even war and other conflicts. But the developments in these areas will occur. They will come. They will happen as certainly as they are issues that confront us today.

So I believe facing up to the basic challenges of producing enough energy and ensuring enough clean water for the Earth's growing population and the nexus between the two will continue to occupy a growing amount of policymakers' attention as they and all of us deal with the ramifications to our economy, to job creation, to our fragile national security, and to many vulnerable health concerns that lie ahead, and all of this occurring within a backdrop of huge and growing deficits and national debt.

I wish I could identify policymakers for you who are displaying more than a simple parochial, seasonal, or maybe even political convenience when it comes to the leadership in these issues. I can attest, having served with many of them, that often the vision that they have, the plan, the scale, the reality is just not there.

It seems that when gas prices spike, as they typically do about this time of year heading toward Memorial Day, politicians get all ginned up with their three- to five-point plans about an energy strategy, and mark my words, we will see that. We've already started seeing it.

But this has been happening for many years, in fact forty, to be specific, since the energy shortages of 1973. You can go back, and on YouTube there is a very good display of all of the presidents since Richard Nixon claiming that we will become independent as a nation with regard to our energy within everything from a year, to five, to twenty to thirty, to however many years into the future, all with their plans to accomplish that.

And we are the boiling frogs, the American people. You know the story of how you cook frogs. You don't boil the water and then throw the frogs into the boiling water because they hop out. The way you boil frogs—if you're interested in this recipe I can get it for you—you put them into nice water and then you start turning up the heat very gradually. And we here in America in particular, I know, are the boiling frogs because every year we seem to have a new threshold of pain when it comes to some of the energy and water challenges that are out there.

As a proud, self-described free market conservative myself, I'd like to tell you that the decisions, the policy solutions, fit into some very neat and tidy philosophical box that can be based on good old-fashioned free market driving forces. In many instances, that may be true. But while the market will most certainly drive in its natural forces toward an end result, these two subjects in-

JIM NUSSLE

dependently and collectively, that so-called marketplace in which they have to compete, particularly when it comes to energy, may be anything but free and open.

So if my simple task of opening this conference is daunting to me, it's going to be completely daunting to our panelists who have to try and come up with some solutions here today. Luckily, I was not asked to come up with anything close to a solution. I was only asked to open things up and begin the discussion.

I hope they challenge our assumptions. I certainly hope they challenge mine. I hope they challenge our biases. I hope they challenge our ignorance and open our eyes to the challenges ahead and create in us the preparation we need to challenge others who are not here today.

As the president of what I believe is the leading ethanol organization and biofuels organization, Growth Energy, I can tell you that I'm often in a position of challenging preconceived notions and policy assumptions about my industry and the competitive market of energy.

You focused on what I believe is our nation's most recognized and significant challenge by focusing on the conflict sometimes between the need for water and the need for energy in the twenty-first century. My organization understands and supports the need for all sources of energy, conventional and alternative.

We believe in an "all of the above" approach when it comes to the future. Everything should be available. Everything should be on the table as we look at strategies for the future.

This approach I also believe can and should have an awareness of American national security, American jobs, and having the final choice in the hands of the American consumer.

I agreed to lead this organization and their supporters for many reasons, but I came to realize as I was a member of Congress and in the administration that ethanol is not just one of our nation's only solutions, it's the only commercially viable alternative to foreign oil we have right now, and we have been able to lessen our dependence on foreign oil just in the last ten years by about nine percent— a good start. More needs to be done.

A little background—ethanol has been in the American fuels market ever since there have been U.S. fuels. Not only did Henry Ford design the first American automobiles, but he ran them on ethanol, and he was the largest ethanol producer starting out in this country. He designed his cars to run on that fuel. Ethanol was our nation's first effective anti-knock ingredient and a low-octane gasoline.

It took another forty years before lead, which was there for anti-knock purposes, was finally banned from gasoline because of health concerns. Ethanol increases the oxygen content. It's obviously cheaper than gasoline, about historically ninety cents cheaper, and we believe that we can survive without the blenders' tax credit that just expired here the first of the year. In fact, our organization promoted the expiration of that tax credit because we believed that it's time for our industry to stand on its own two feet.

So if ethanol is good, why aren't we all using it? Well, you could argue that ethanol as a small case study, and maybe this is the reason why I was asked to kick things off, is just that — a small microcosm case study of so many challenges that are out there facing just the energy side of this equation.

Let me explain that briefly. In 2005, Congress adopted the renewable fuel standard. It expanded it in 2007 as part of the Energy Independence and Security Act, setting a mere goal of 36 billion gallons of renewable fuel in our liquid fuel supply by 2022.

Believe it or not, this is the first long-range strategic energy initiative that we've had since the energy crisis of 1973. After hearing forty years of speeches from both parties on this, it's about time we had at least some strategy with regard to the future, even if you don't agree with every point of it.

But, again, as a case study, even as we have the renewable fuel standard, there are other rules that are on the books or that have been put on the books subsequent to that that make it difficult or prevent biofuels from meeting the very standard and the very goal that was set. One rule is the real barrier that we have to entering the market right now, which is the Clean Air Act's definition of motor fuel. The Act defines motor fuel as gasoline. There's no other definition. And so unless you are gasoline, there is no way to get into the motor fuel market—just an interesting aside and one of the hurdles that you have to jump if you're going to build not only the strategy, but the regulatory framework around it. I point that out just to give you an example because my organization battles these on a very parochial industry-specific basis. Many industries do the same thing.

All of them together may not be pulling the wagon in the same direction. One of the challenges that I hope you consider here today is how you get all of those different interests that need the market to help determine their future to pull in the same direction. I'm not whining. They're just real-world experiences that we've had in our industry that I point out as ways or examples that you may want to consider.

So I suggest that the renewable fuel standard is a tool or maybe an example, maybe a case study, of what might be done, what could be put forward in order to deal with some of the challenges. Let me end by saying that I think most people in this country take the issue of water and energy for granted. We have a very distracted electorate and a very distracted citizenry for various reasons.

The mere fact that you have taken the challenge and the focus to try and deal with these key issues for the twenty-first century is a testament to Hudson and to the leadership here in trying to set up the conversations for the future to get us focused in order to solve the great American and international problems of our day.

So I look forward to the discussion today. I hope to walk away maybe a little less biased and a little bit more knowledgeable about these issues than when I walked in, and I congratulate you on the conference. Thank you.

Panel Discussion I

Energy, Water, and Debt: Linked Problems, Common Solutions?

Moderator:
Lee Lane,
Visiting Fellow,
Hudson Institute

Speakers:
Craig Zamuda,
Senior Policy Adviser,
Office of Climate Change Policy and Technology, Department of Energy

John Lyman,
Director,
Energy and Environment Program, The Atlantic Council

W. David Montgomery,
Senior Vice President,
NERA Economic Consulting

LEE LANE: Hi. I'm Lee Lane. And let me add my thanks to Grundfos for the support for this event. And thanks to all of our speakers and to all of you for your interest in the subject.

Our first speaker is Craig Zamuda of the U.S. Department of Energy. Craig is a senior policy adviser in the Office of Policy and International Affairs at DOE. I have fairly wide contacts at DOE. And I asked pretty much everybody I knew at the beginning of this process who the right person from DOE to talk about the nexus between water and energy was. And every single person to whom I talked said Craig. So obviously, Craig is well positioned to tell us what the DOE take on the accommodation of these issues really is. And I look forward to his remarks.

John Lyman will be our second speaker. John is the director of the program on energy and environment at the Atlantic Council. John is also the co-author of a report that we have available for you to read. The report actually does a good job of the main purpose of this panel, which is to raise the basic issues associated with the interface between energy and water within the context of existing fiscal restraints. Interestingly enough, you'll see from John's bio on the sheet we provided that he also has a background in the oil and gas industry. I'll be very interested to hear about the combination of viewpoints that result from someone with such an interestingly diverse background.

The third speaker this morning is my friend and occasional co-author, David Montgomery. David is senior vice president at NERA Economic Consulting, a firm that he just recently joined. He has had an extremely distinguished career in Washington in which he held senior management positions at both the U.S. Department of Energy and the Congressional Budget Office. He's been an author as part of the "working group three" of the second assessment report of the International Panel on Climate Change. David has spent a long time developing expertise on assessing the impacts of regulatory policies, with an increasing focus on the political economy of how policies get shaped and why they turn out the way they do.

CRAIG ZAMUDA: Well, first of all, let me thank Ken and Lee for this opportunity. I'm not sure if it's an honor or a liability to be indicated that I'm the guy to talk to on energy and water within the Department of Energy. But let me say that the Department of Energy is a large entity. Our focus is on energy security and we recognize that issues like energy and water are going to be key as we look forward to the rest of this twenty-first century and the challenges that we're going to have to address.

What I'm going to try to do today is cover some of these major challenges that we see, some of the things that the Department of Energy is doing in this energy-water nexus, and talk about some of the challenges and policy issues that lie ahead—viewing them not so much as issues and challenges, but as opportunities as we move forward. With regard to this energy-water nexus, I'm going to try to drill down a little deeper than Jim did and provide a little bit more background to set the stage for the conversations that will follow.

Needless to say, one of the reasons why the Department Energy is interested in this issue of energy and water is the recognition that without significant amounts of water, we can't maintain and sustain the energy sector or the energy infrastructure that we have today—it is very water intensive, both the amount of water that's withdrawn from surface-body waters and ground water, and also the amount of water that's actually consumed. I won't get into any technical details about that differentiation. I'll just leave it at regardless of what technology you're looking at from the energy perspective, they are all fairly water intensive. And on the flip side, with regard to water—extraction water or transportive water, use of water, treatment of water—it's very energy intensive.

The amount of water that we withdraw on a daily basis for production of energy is on the order of forty-five percent of the water that's withdrawn in the United States. The amount of energy we use to produce the water that we use ranges from five percent upwards, to (in some locales) on the order of twenty percent in the state of California, where there's long-distance transport of water. So both of these are very linked. And as we look forward and look at the issues of sustainability, for example, of a growing population, of growing energy and water demand and lay on top of that additional stress multipliers such as climate and the effect that climate might have on the hydrologic cycle, we begin to recognize that the current system we have in place may not be the system that is sustainable over the long term—and what do we do about that?

And I'm just going to end on this note, before kind of getting into some of the details of the presentation, that even some of the solutions we're looking at—even some of the policies we have in play—may actually be exacerbating the problem. And we need to make sure we're looking at what the consequences are of the policies that we have in place, as well as new policies, to avoid unintended consequences with regard to this energy-water nexus issue.

With regard to climate impacts on the energy sector, I won't dwell on the range of impacts that are up there. Let's just say they're more than just droughts and water availability. In some cases it's the lack of water, in some cases it's too much water. It's kind of like "Goldilocks and the Three Bears" where you're trying to get "just right." But in many cases—at least on extreme events—we may find that the amount of drought or floods that we're encountering and other issues such as sea-level rise, temperature change, et cetera, are going to have impacts across the entire energy sector—not just on electricity production, but also on transportation of fuels. So on the whole value chain from extraction of resources to processing to refining to use, we have this issue of the water-energy challenge and one that's going to be perhaps further challenged as we move forward in a climate that's changing.

So what are some of the constraints? We have increasing energy demand; whether you're looking at this from a global perspective or a domestic perspective, all projections say we're going to need more energy as we move forward. And in many cases, that energy demand is going to be coming about in regions that are already water strapped.

We have increasing water demand not only for the energy side, but for other sectors that are requiring water—agriculture, residential, industrial, et cetera. And the gap between the available water and the water demand is going to keep increasing. Some projections are saying over the next couple of decades that the gap is on the order of forty percent on a global basis.

And so we're looking at climate change as being an additional stress multiplier to this. The changes in the hydrologic cycle are only going to aggravate this situation. Some of us—John Lyman and I are coming from a meeting earlier today where we heard a presentation from the National Intelligence Council—represent the National Intelligence Council that will be providing a report coming in the February time frame looking at the stress that water is going to be placing on a global perspective and the potential threat that that has for not simply energy security, but national security. So these are growing challenges that we have before us. And what I'd like to focus on is some of the things the Department of Energy is doing to address these challenges.

For those that aren't familiar with the Department of Energy, a simplified characterization of our mission is to ensure energy security. We have other aspects that are more tied to national security, such as the nuclear weapons complex, but I'm going to focus more on the energy side of that. We have a billion dollars of investments at our national labs with expertise that can address breakthrough technologies and technological solutions to some of the problems that we're going to need to address to ensure that we do have an energy sector that is water efficient, if you will, and energy efficient, and is going to be ensuring energy security as we move forward.

How will water constrain energy production as we look to the future? There have been a number of studies by our national labs in collaboration with universities and the private sector to look at this issue and characterize what the state of play will look like in the next ten or twenty years. I'll just highlight this one study that was done by our National Energy Technology Laboratory, which was demonstrating that of our nation's coal-powered electricity-generating plants, which are a significant contribution to the electricity generation in this country, a significant number of those plants will be vulnerable to water stress across the country, and not necessarily simply in regions that we're accustomed to be thinking about such as the arid Southwest, but in other regions such as the Southeast. So we'll need to be doing a better characterization of what will the future look like, both from a climate perspective and a water-availability perspective, as well as the impact of water availability on the energy sector.

I mentioned a moment ago some of the

policies we have now and their implications. Jim commented a few minutes ago on the requirement for roughly thirty-six billion gallons of biofuels by 2022. Those may be excellent policies to have in place, but they come with some consequences in terms of where the water is going to come from if not for irrigation. If we move away from traditional bio-fused crops to crops that don't need irrigation, you're still going to have a water footprint associated with the refining aspects. So there's an aspirational goal out there. What does that mean from a water perspective?

Some of the other technologies we're looking at are carbon capture and storage. One way to minimize the CO2 emissions from coal-fired power plants or gas-fired power plants is to implement carbon capture and storage technologies. An energy penalty is associated with capturing that carbon dioxide. The energy penalty, in turn, translates as a water penalty, because it takes water to produce the energy. And some projections suggest that we're talking about anywhere from a fifty to one hundred percent increase in water needs to operate these plants if there's a full-scale deployment of carbon capture and storage.

So as you go down the list, we see that there are policy implications in terms of what we're doing, whether those policies are tied to energy production or whether they're tied to environmental concerns such as the Clean Water Act and the 316(b) regulations that some of you may be familiar with where, in essence to protect the ecosystems, we're moving away from a lot of thermal loading of those systems and looking at alternative ways to reduce potential ecological impacts. One of the traditional ways is to use cooling towers. And the good news with that is that you significantly reduce the amount of water being withdrawn. The bad news is that you significantly increase the amount of water that's actually being consumed. So there are these implications.

The last one I'll point out is this idea of being energy independent. We need to recognize that to do that, we're going to increase the amount of extraction, of refining that's going on in this country, which means there's a water footprint associated with that. And so there are implications with a number of these policies. The key is to ensure that we avoid unintended consequences and that we understand the value chain of these processes and the impacts this has as we move forward.

For the rest I'm going to really focus on: what is DOE doing about this? I will lay out several pillars of our focus. One is to increase our scientific understanding of both from a climate perspective in terms of the energy perspective and how do we model these systems so that we're able to project at the scale that we need? What might be the implications of moving beyond global circulatory models to be able to downsize this to the degree that local decision makers can be making decisions about whether it's appropriate to site a particular plant, et cetera, and what the implications would be.

We're also looking at ways to increase the water efficiency and energy efficiency of the technologies that we're developing and deploying, ways to look at advanced cooling technologies, moving away from the traditional evaporative cooling process through cooling towers or once-through cooling processes, and moving toward dry or wet-dry hybrid systems for which there's a significant reduction in the amount of water that's used in that process. Today, that's being done; it's being done at certain plants across the country, but there is an energy penalty associated with that. There's an increase in cost for using dry-hybrid type cooling systems, and we're looking to see how we can reduce those costs.

I'm going move through some of these quickly. I assume that these materials can be provided to attendees afterward, so I welcome you to come back and look at this. Some of the work we're doing crosses the bridge from technology development and from the science, to support that we're providing to the private sector, to other state and local governments, and to other entities of the federal government itself. I'll highlight some of the work we're doing out west with the Western Governors Association where we're doing some modeling work to look at what the future would look like in terms of generation and transmission of electricity, what the implications might be from extreme events and climate change, et cetera, and be able to better position them in terms of planning for the future.

In terms of the advanced cooling, I talked about some of these dry hybrid or dry systems or wet-dry hybrid systems that are in place. There is an example of a plant out in New Mexico that uses this dry system for cooling and significantly avoids consumption of water. Increasingly, states and locales are looking at these alternative cooling technologies to avoid the water implications with these plants.

With regard to creating additional waters, if you will—water recycling, using of nontraditional water—a lot of emphasis is being placed on that in the Department of Energy, looking at wastewater, looking at saline waters, looking at waters from oil- and gas-produced waters, and using these to avoid the use of fresh water.

Oil and gas water research that's going on: you can't go a day without seeing some story about the unconventional gas development in this country—a real boom to the economy. There are some challenges with regard to water quality and water quantity. The average well in the Marcellus Shale is characterized as requiring one to three million gallons of water. So there's a water footprint there. And we need to better understand how to reduce that footprint and how to recycle the water so that we don't run into issues of water contamination as the technology expands even further in the future.

Those are the types of things that are being focused on directly by DOE with regard to the energy-water nexus, but there is other work that we're doing. I'll highlight the Energy Star program that celebrates its twentieth anniversary of this year. Savings—whether it's through appliance efficiencies or through building efficiency—any energy savings translate directly to water savings. We don't package those programs as being water-saving programs; we package them as being energy saving programs, but it's a twofer. We probably need to do a better job of characterizing what those water savings are. The estimate for 2010 for the host of Energy Star programs was a savings of about 240 billion kilowatts of electricity. If you did a back-of-the-envelope accounting, that's about 500 billion gallons of water saved in the process. So there is this nexus. We don't want to lose sight of things that we can be doing and are doing that result in both energy and water savings.

One of the last points I want to make here is that over the last year, the White House has taken the lead, recognizing that no matter how successful we are with regard to climate mitigation and the deployment of mitigating technologies, the climate is changing. The direction went out to all the agencies to start doing adaptation planning, and that has cascaded into certain activities that each and every agency's been responsible for doing—preliminary vulnerability assessments, looking at the mission of their respective departments, to look at how climate will impact that and what actions they need to take.

One of the follow-up actions that we're pursuing in the Department of Energy, having already done that preliminary study, is to be looking at the energy sector. One of our goals over the next year—and basically by the end of the fiscal year—is to have done a better job of moving beyond the qualitative characterization of the impact of climate on the energy sector to a much more quantitative one—even including some detailed modeling information. And over the next year, then, our goal is to be working with other agencies, working with the private sector, working with universities and other organizations to try to come up with a better characterization of what is the potential risk to the energy sector. What are the things that we need to be doing and priority things that can be done to make the energy sector more climate resilient as we move forward?

So, in summary: The perfect storm may be brewing out there that we have this combination of a number of factors between population growth, increased energy demand, reduced water availability, et cetera, that may actually pose a threat to energy security. We need to be aware of that and doing a better job characterizing how real that situation is and what do we do about it. There's the need for greater resilience in the energy sector, as I talked about.

I will lay out four potential areas that we can actually pursue today. One of those is better modeling information. It's very difficult for a decision maker—whether you're in the private sector or whether you're in a government sector where you're a permitting facility—to take action unless you have accurate information, accurate data to characterize what the implications are for those management decisions. So, we need better and improved models.

Second, we need better technologies that are both energy and water efficient.

Third, we need greater public awareness. I mean, I think one of the themes of Jim's comments was, we take all this for granted. We take the energy for granted; we take the water for granted. We want cheap energy; we want cheap water. When we're in a position where we're watering our yards and we're washing our cars and we're drinking water, that says volumes about, is this a real issue for the future or not?

The fourth and final point is, we've typically operated in stovepipes—whether we're talking about how the government is organized or how other institutions organize themselves around issues. There are the water people; there are the energy people, and on and on and on. We need to recognize this is really a holistic problem, and we need to have much more of a synergistic approach. We need the government agencies working better together; we need the disciplines working better together. We need the government working with the private sector in a greater partnership. There's a lot of opportunity here to lay out the solutions for the future.

So I'll stop there and take any questions, if there are, later on.

JOHN LYMAN: Well, I want to make one correction here—it is that the report that was just written by the Atlantic Council was actually written by my client, who's sitting here in the audience. And it's part of a three-part series, in which we dealt first with the electric power sector that I'm going to talk about this morning; second, we're dealing with the impact of the nexus on primary fuel production; and we're about to do a third part dealing with municipal and industrial treatment and processes.

I think where you want to start with is this: Why is this important? Craig did a terrific job of laying it out. I don't know how many of you know that the Indian Point nuclear power plant with ENERGEN on the Hudson River will not receive NRC license extensions unless it meets New York State regulatory requirements, who are trying to force ENERGEN to spend $2 billion to protect Hudson River fish. Those plants provide thirty percent of the power for New York City. This is a real problem. And this is a problem caused not by energy versus energy and water, this is the need for the nuclear power, while at the same time you've got to protect fish and wildlife and the river. So these problems are here; they're coming. And this intersection as you pointed out, is real. It's on us, and we really need to move forward.

So when I was asked to discuss what the challenges are, the first challenge I thought of goes to the speaker of the day and to the last one—we need to capture the attention of the public and Congress. It's a major problem. Currently, there's no overwhelming public pressure on Congress to act. We've learned that from congressional staffers. It's a real problem. The public isn't out there saying, you've got to deal with this. Hopefully, events like today's will increase that kind of pressure. And Congress is paying a lot of attention talking among themselves, but they don't have the public pressure to actually pass legislation.

Now, the other thing I would like to talk about is that national statistics can be misleading. I completely understand why you talked about withdrawals. Forty-one percent of all the withdrawals for water in the United States are for thermal power alone. Forty-five percent is the total energy withdrawal. Forty percent of the withdrawals are for agriculture. So power plants withdraw as much water as agriculture does; however, the consumption figures are totally different. The consumption figure is that about eighty-one percent of it is agriculture and only three percent is thermal power. So some people say, well, what's the problem?

Well, the basic problem is that as the demand for electricity grows—which is happening, even with increased energy efficiency; and you saw that on the earlier slide—and even though the water consumed for electrical power is relatively low, we're bumping against other uses. We're always in conflict. So even though there's only a three percent power-related consumption that could increase by up to sixty percent by 2030. So even though that's a small percent, it's taking it away from somebody else.

Now, more importantly, it's taking away water in a world where there's decreasing availability due to declining aquifers and reduced river flows. Climate change is definitely affecting river flows. If you live out West, you would really understand that. If you live down in Georgia, in Atlanta, you would understand that. But you know, here in Washington you don't see it as much and other places you don't, but it's a real factor in this country.

Since accessible water resources are not increasing, we have to realize that with population growth, which the United States is fortunate enough to still have, we will decrease per capita water availability. So we're all going to have to share water more than we did last year and the next year, and it's going to get worse and worse and worse with population increases.

And just as importantly, regions experiencing the greatest population growth are those already under water stress. This is becoming a critical problem to states, which you probably have heard of with California, the Colorado River problem, Nevada, Arizona, Florida, et cetera. And even Atlanta, Georgia, faced this problem last year.

Cooling water withdrawals and return to the source—it sounds like that shouldn't be a problem; they've returned the water. But that's not really just the issue, because what you have is you're also taking it away from somebody else. And more importantly, as you return the water, the intake and the output flows often impact aquatic life. That's what was going on with the Hudson River problem with the nuclear power plant. So you get issues that seem to be removed from just the simple issues.

Fortunately, water withdrawals for power have remained fairly constant since 1980. That sounds great. However, these restrictions to meet these multiple requirements have already led to the shutting down of some power plants and more can be expected. So while we've held water withdrawals flat, it's still a problem, because there are increased water needs for other things and we're actually having to still shut down some power plant availability due to water concerns. And you saw that in the NAPL data, which says that this is going to be a particular problem for coal plants; it could be a growing problem for nuclear plants. So we do need some new technologies.

Resolving this kind of conflict is going to require sorting through a huge number of trade-offs. This is not an easy, "oh, I've got the answer." And that is because the issues are local; the issues are site specific. It's not like you can sit down and say, "Oh, I've got a national set of answers for all of this." You've really got to think it through region by region, state by state, watershed by watershed.

It's also going to be a problem, because you're going to have to tradeoff between the problems of the water actually consumed in the plant—in other words, what's been taken away after—with the flow back, as well as the cost of various pooling and generating technologies. In our reports, you will see a lot of those numbers presented. But different technologies consume different amounts of water and cooling, and different cooling options consume different amounts of water. And so you clearly find dry cooling as consuming the least water. And in fact, I think there are some states that have insisted that there will be no more plants put up without dry cooling. That increases cost. So one of the other issues that comes up is we're going to have to live with some cost increases that the public is going to have to get used to.

Infrastructure investment to increase access to water resources has remained minimal for decades. For example, despite growing limitations on fresh surface water and ground water supplies, there has been little increase in surface water storage since 1980. In other words, there haven't been any more reservoirs built. We're living with a 1980 infrastructure in water storage.

In arid areas, underground resources are replenished very slowly. You say, well, doesn't the rain come and replenish that? Well, that's not what's happening, because in an arid area, you don't replenish faster than about half a percent a year. So in fact, we're mining the water out of the aquifers. This is a major problem in parts of the United States. Again, in the document we have, we have maps which show where this is a bigger problem than elsewhere.

Again, your answer is, well, I'm going to utilize marginal water. That's saline water or municipal water, et cetera. That is being done in some places. But the utilization of that takes increased amounts of energy to treat and to transport.

So we've got places in the world where you've got vast quantities of U.S. fresh water supplies, but they're not easily recoverable areas, likes streams or lakes. And the fact that areas of high-water requirements, such as urban areas and farm lands, are not always located close to available water supplies compounds the challenge raised by limited access to water resources. Phoenix and Atlanta come to mind right away.

Now, as you keep going through the challenges for the industry that they're going to have to deal with for electric power, the power industry also faces significant regulatory uncertainties and increased cost. EPA changes to sections 316(b) of the Clean Water Act will impact cooling water intake structures and potentially impact up to six hundred steam-driven generating facilities. That's almost half of all the steam-generating facilities that we've got. I'm not saying exactly how that will play out, but that's in the cards.

New EPA regulations may impact the volume withdrawals for cooling purposes to reduce the impact on aquatic life. Steam electric-power generating "effluent limitation guidelines"— ELGs for short—have not been revised since 1982. These will address the release of toxic pollutants such as mercury, selenium (which is a banned substance, you see a lot of it out of coal mines), and arsenic.

We then have a whole host of issues related to Congress—which I think we've heard talked about this morning as well. Congress does not have the national data needed to develop legislation. We have not kept up with making the right information available to policymakers. So it's great to talk about this, but if you don't have the data, you can't design a very good set of policies.

Second problem: committee jurisdiction is fractured. You've got lots of different people. Not only do you have a problem in the government itself; you've got a problem on the congressional level with too many committees dealing with the same subjects with overlapping jurisdictions. Another big problem is that the amount of investment that is going to be needed to address the requirements is huge, making it difficult to reach decisions in the current environment. And another problem that we can't dismiss is a lack of cooperation in the existing Congress, which makes it difficult to pass any major legislation.

At the federal government level there are issues for the federal versus the state bureaucracy. Water is viewed as the responsibility of the states, but water availability is impacted by watersheds that cross state boundaries. So, right away we have a conflict between the existing rules, and you can get all kinds of state rights arguments with people saying, stay out of the subject. And yet, somebody's has to get into the subject.

The scene is further complicated by the Department of Interior controlling most hydro facilities in the country. They are a major source of power in many western states, as a lot of you know. While this is often thought of as a renewable source of power, it's also being affected by climate change, because in fact, the level of water behind many of the dams is diminishing. All you have to do is go out and see the Hoover Dam.

Limitations to the information and data collected by federal agencies needed for the understanding for advanced cooling technologies, power plant water consumption, use of alternative water sources, and withdrawals versus consumption—again, you saw all those listed by the Department of Energy. They're all working on them; they know that problem, but there's a lot that needs to be done.

Another problem at the state level is that only a few states have catalogued the status of the energy-water nexus in their state. Only nine states have any statute related to the subject, and only Arizona, California, and Colorado specifically address the water-energy nexus, per se, in state laws and regulations. Issues at the watershed level will require coordinated planning among states and federal authorities. Some people may not like that, but it's going to have to happen.

Lastly because we were just talking about electric power, you're not going to solve the energy-water nexus for power without also considering impeding agricultural sector need. That was obvious with what Craig put up, but it's a huge subset of the issue. Similarly, as we've discussed with our primary fuel production, you're going to have to take into account the impact of primary fuel production. And right now you've seen lots of information related to concerns over the impact of shale oil and gas production on water quality. This is an issue that is going to have to be dealt with. People have misled a lot of people talking about just the fracking problem as though that's the big problem. The fracking problem is not the big problem, because you can cement wells properly. The big problem is what happens when the water is brought to the surface and how do we treat it and what do we do with it? And that's a huge problem, and it's going to demand a lot more attention.

In conclusion, linkages between energy and water have grown much more complex and more interrelated and interdependent. Solutions need to integrate with one another. They need to integrate the development of energy and water management policies; they need to support the private sector in implementing innovative technology; they need to support needed infrastructure investment; and they need to support the conservation of energy and water; and they need to support important pricing policies for energy and water throughout the country.

Thank you very much.

DAVID MONTGOMERY: Thank you. It's very good to be here. Lee, thank you for inviting me. I'm always very happy to be back here at the Hudson Institute, because I never fail to observe an interesting discussion and a very energetic audience. So I will try to just make a few points.

Lee asked me to talk about energy efficiency. My presentation is a little bit different in scope than the two you just heard, in that I'm not going to try to survey the entire space of energy and water issues, but rather to talk about one topic that comes up in just about every presentation on those issues, which is that "if we would just have more energy efficiency, we could get around all of these conflicts." And I want to suggest that that is a very incompletely informed view of the subject.

But before I start on that, I can't resist commenting: John, you just got to the good part in the last three words you said, which is if we would just price the water, most of these insoluble conflicts would be handled in the marketplace.

And that's not too far away from what I'd say about energy efficiency. There have for a very long time been two points of view about energy efficiency and two ways of studying the problem. It's sometimes called the efficiency gap; it's sometimes called the conservation paradox. I prefer the conservation paradox, because conservation is a good, old-fashioned term, which goes back in my mind to Teddy Roosevelt and national forests and the notion that we are making an explicit social choice that some things are worth protecting beyond the point of their economic value.

The notion of energy efficiency has recently gotten itself very much wrapped up with the notion that energy efficiency is simply good for us, that there are—as some of my recalcitrant economist colleagues say—$20 bills sitting on the sidewalk everywhere that people just refuse to pick up, because of the opportunities for both saving energy and saving money at the same time. And this is what's characterized as the conservation paradox. That it's so cheap and so good for people, but they won't do it at all.

Well, that obviously suggests that there are two methodological ways of approaching this. One is to do your calculations and figure that people are getting it wrong. The other is to look at the markets and figure that the calculations are wrong. And that really has been the debate for twenty years.

What we might call the free lunch view is that energy users are ignoring opportunities to save money and save energy at the same time. We see this in the famous curves that another consulting firm, McKinsey, walked around Washington and other places for several years claiming that we could get most of the way toward a 2020 goal for reducing greenhouse gas emissions through energy efficiency and it would actually save us lots of money. And EPA and the current administration continue to make similar points about why energy efficiency programs will save money and create jobs in this economy.

Now, the other point of view is that markets work; that energy is priced in a market; that individuals face the consequences of their decisions and make rational decisions. So that if we're going to reduce energy use beyond the point that it evolves to in the market, there's going to be a cost to doing that. This point of view doesn't lead directly to a policy conclusion. The question then is: Are the prices of energy right that people are responding to? It doesn't say we should do nothing about energy use, but it does say there is going to be a private cost of lessening energy use. And that that cost has to be justified by some external benefit in terms of climate or air quality or energy security or some other public benefit.

Now, how are these calculations done? The direction of inference in the free lunch point of view is very clear, because we see these studies—well, certainly back to the twenty years I've been in consulting, because Lee actually hired me to take a look at a study that came out just about twenty years ago from the Union of Concerned Scientists going through exactly this process. It was what I worked on in the second assessment report of the IPCC, trying to characterize this literature, and they keep on coming. And essentially, the calculations are all done in the same way. You look at the costs of a piece of equipment that would be more energy efficient, calculate what that would cost—sometimes what it would cost to install, and then calculate what the reduction in energy use is. And they price that out at some projection of market prices over the life of the equipment. And in present value terms, discover that there is a large net saving for the consumer. And this then leads to the inference that consumers must be getting it wrong and policies are required to do something about it.

Now, for an economist, we introduce the concept of market failure, which is that if the market's working, people are at least going to be making the choices that are in their own private interests. They may not be in the social interest, but you can be sure that it's a worthwhile working assumption that people are not wasting their own money on the things that they're buying. And so in order to support the notion that policy intervention is required when the engineering studies say that people could save money, there becomes a search for the market failures that would justify that assumption. Most of them tend to fall into one of two categories: the price is wrong in that the price that individuals are looking at does not really reflect the full cost of energy. Now, if that's the case, the problem is not one of people making the wrong decisions; they're being faced with the wrong terms. So that's not really the energy efficiency paradox. That's easy to explain and in fact, pretty easy to figure out what to do about it, as we did.

The bigger problem is that most of the other places of kinds of market failure are one form or another of information problems. They're either the problem of lemons—that is, in resale markets like for houses, people don't believe what they hear from the owner about how low their energy bills are. Returns to scale—information is expensive to collect and cheap to disseminate so individuals may not be able to pay for the right amount of information. Sometimes discount rates are blamed. People show they have such huge discount rates for buying energy-efficient equipment. Well, that's just another way of saying this calculation has been done, but there is some evidence that some people really do have high discount rates, based on the risk of new technology, based on their own status as debtors and their ability to borrow money. So these all come up there, but we tend to look at market failures as a reason.

The direction of interest from the point of view that markets work is that energy markets in the United States have over a period of years come to reflect pretty clearly and accurately the private costs of producing energy. It wasn't always that way. When I arrived in Washington, natural gas was regulated, prices were regulated at the wellhead at 50 cents, and we had natural gas shortages and allocation. Gasoline prices were regulated at the pump and we had gasoline lines. Electricity prices were based on average cost, even though the cost of new generation was going up and up. So we had excessive consumption of electricity. We fixed all that. We had an era of regulatory reform, which pretty much got pricing right for everything. Things looked good in 1990.

Since then, we have been laying more and more subsidies into the system for particular forms of energy. Usually, tax breaks for oil companies are blamed for this. My analysis and that of the Energy Information Administration was that on the margin, the subsidies for oil and gas production really don't affect production. They're all directed at small producers and are limited, so that you don't actually get more subsidies when you produce more oil and gas. That is not true of renewables, and it's not true of energy efficiency. So we have been significantly distorting the market, but it's toward ethanol and other renewable fuels and toward energy efficiency, and that helped us to geothermal heat pumps, which I just got a huge energy credit for replacing in my house.

So in this case, the methodological approach is that if energy users seem to be making irrational decisions, the next step is to ask what's going on there? Is there a market failure that can be addressed or are there simply hidden costs that are not addressed in the engineering calculation? A lot of times that's exactly what we see. Mark Jaccard, Simon Fraser University, has had a major research program on this for many years, since he and I wrote a chapter together for the IPCC volume. And his research has suggested that one of these three things is most often going on in the engineering calculation.

The first one is they simply ignore system-level effect and interaction. So they add up an improvement in fuel economy of vehicles and then they add onto that a reduction in energy use from VMT from reducing driving that was based on the assumption that you would not have improved the energy efficiency of the vehicle. So they add up a lot of measures that are sub-additive and they come up with far too big a number for what could achieve with energy efficiency.

The second thing is that they all ignore hidden costs. Aside from Mark's work, there really has been no serious market research to try to quantify what it is that consumers really care about, except for what motor vehicle manufacturers do to figure out how to price the attribute of the vehicle, which is one of the reasons why I fail to believe that there is anything particularly wrong with motor vehicle prices, especially in terms of their fuel economy, because the motor vehicle manufacturers have a very clear idea of exactly how much consumers are willing to pay. And they generally have found that they're willing to pay too much for fuel economy, not too little.

But the real hidden costs are things like CFL. The color temperature of compact fluorescent light bulbs was intolerable for a long period of time. Their usability in existing wiring is still almost nonexistent. Far too many fixtures can't safely use them, either because of the shape of the fixture or because of the nature of the dimming; and then there is the mercury hazard. So all of these things are left out. Diversity of use is also not considered. The calculations are done based on some notion of average use, which may or may not be correct. But the most important thing that is left out is the inference that there should be standards. For example, the standard to ban incandescent light bulbs. I have a closet where the light goes on maybe five minutes a year. It's totally irrational for me to put anything except the cheapest incandescent light bulb in there, because I'm not going to pay back anything else as a light source.

And finally, the institutional obstacles. In fact, there are major institutional obstacles to pricing both energy and water. These obstacles seem to me to be the real culprits here. And on the energy side, the problem I believe—and this is where Lee is talking about the work that we've been doing on energy and on political economy—is that in our political system all of the motivations for elected officials are to hide the costs and to highlight constituency service. Appropriately pricing carbon or anything else about energy makes its cost very visible. And therefore, what we have substituted for a pricing system is a large number of regulatory measures, efficiency standards, renewable fuel mandates, subsidies for this, that and the other thing. These measures have two great attractions to Congress. The first one is they hide the cost; and second is they provide very specific constituency service. That's the real institutional obstacle, I think, that we're dealing with on the energy side.

On the water side there's another problem, which is that the regulatory measures [prevent market transactions that would benefit both buyers and sellers]. Even if we believe that there are substantial market failures affecting energy use of the information-based kind that I have been describing—and I do not think there's very strong evidence for that, but some others do and are working hard at that issue—the point is that if that's what we're going after as the reason for the efficiency gap, then the answer is not the current randomly chosen collection of delivering subsidies, mandates and regulations. It's to do something which actually goes at the market failure itself. And frequently, market failure can be addressed in a "do no harm" fashion, by which I mean, "provide more information." The labeling requirements cost something—no doubt about it—but they left the decisions up to people so that if it turned out that the hypothesis that there was a market failure, and the hypothesis that there were no hidden costs was wrong, people would go ahead and make their decisions a bit more informed, but they might still choose the same thing and that would be fine, if it would remedy the market failure.

And leave it for an exercise for the audience, but think of other examples of how a market failure is, actually—for example, if you don't address a market failure—for example, the rationing of credit to lower income people but demand that everyone pay more for their refrigerators for the same capacity and utilization, then all you are doing is forcing those lower-income people to bear higher credit charges or to do without. So if you don't fix the market failure, sometimes all you're doing is forcing people to bear the costs that you weren't able to recognize were there.

And it would be very useful to think about how to apply similar thinking to water quality and to water problems. Though the more I have thought about that, it strikes me that the problem really is that the price on water is either zero or infinite. No surprise that when something has a zero price, there's an immense and unsatisfied demand for investment to provide more of it.

On the other hand, we have a lot of cases where the regulations for water use essentially say that the price is infinite. You may not run the water through your power plant in New Jersey and dump it out at the Delaware Bay, unless you make sure there's no fish food coming out with it and the temperature doesn't increase. Well, that's an absolute standard. We can't ask the question, Is the value of the Salem power plant greater than or less than the value of the fish that would be entrained by a once-through cooling system? The evidence, I would say, is clear. The most popular place for sport fishermen in Delaware Bay is at the outflow of the Salem power plant, because that's where all the big fish go to eat up the little fish that got chewed up in the power plant.

And so with that I will stop too with the point that if we had anything resembling a system of property rights in which you could buy and sell water, it would eliminate, I would speculate, seventy-five percent of the issues that we're going to agonize over, about water policy.

Thank you.

LANE: OK. I've got to resist and extremely strong temptation to jump in and ask questions of my own and throw things open to questions or comments from the audience.

Q: **Blythe Lyons**, Energy and Environment Program at the Atlantic Council. Thank you one and all. Great perspectives.

I would like to ask Craig Zamuda: What will it take to get a really great national database on water use—consumption and withdrawals—and plot it against the available supplies? Do you need legislation? What do you need?

ZAMUDA: Well, let's address what we currently have in place and then go from there. So we have a couple of agencies today that collect water and energy information—the Energy Information Agency collects a lot of information on an annual basis and makes that available on their website in terms of energy use, and there's some water information associated with that. USGS routinely also is collecting information on water availability, water supplies, water use. So there are existing databases out there.

Just some truth in advertising: There was a study done by the Government Accounting Office about a year or so ago that reviewed those systems and identified some additional opportunities for improving those systems. There's certain information that's not being collected. For example, the use of nontraditional waters is something that's not collected. That might be very beneficial information.

So I think the short answer is there are systems out there today. There's always a challenge of the burden placed on people that need to provide that information and the concern about how much burden to place on the private sector to provide information along these lines that would be very valuable and very useful, but could be time-consuming to be able to provide.

But we do have mechanisms in place. We don't really need new legislation to be able to collect that kind of information. In many cases, it comes down to resources. And historically when you look at the information that EIA has collected in some cases, just because of budget considerations, they literally had to scale back on some information that was being collected.

And so with the advent of the GAO report and the recognition that both the USGS and DOE need to perhaps partner in terms of data collection so that they can better complement and supplement one another, I think there are improvements under way, without any additional legislative activities necessary to help feed that.

Q: **Fred Smith**, CEI, former employee of Lee Lane. As a matter of fact, it's very good that water policy is finally getting to the top. We did a conference in 1997 in Texas during a drought on why water and oil policy might mix and then of course it rained and they forgot about it. But that's a point I'd like to focus on here.

It is ironic that energy sustainability is so much more vital than water sustainability. And let me suggest that energy is largely privately owned. It's in the property rights regime, and that's an artifact largely of the U.S. innovation—institutional innovation of subsurface mineral rights.

Water is largely in the political domain and creates much weaker incentives for lesser things. That suggests a lack of pricing. If something's not owned, it's much harder to put a price on it. And institutions may also be lacking geophysical data. Look at the amount of information we have on oil supplies, gas supplies, and so on, because there's an incentive to find out on what terms you could own it.

And then the lack of innovation is very serious. Shouldn't there be—and maybe the next panel is actually going to deal a lot with this—the possibility that we could just amend the subsurface mineral rights laws to allow—at least enable—individuals to acquire ownership of aquifers, because most of the water is in aquifers?

And if we could begin to create the institutional changes that have made a quart of oil less than a quart of water in our drug stores, we would unleash a tremendous amount, rather than [using] demand-side management, which is top-down and trying, it seems to me, to make something work in a much less efficient way. Thoughts, impressions?

LANE: Professor Libecap is, in fact, going to be talking about property rights with relation to water in the next panel. But I'd welcome any comments from the current panel on that subject as well. Anyone?

MONTGOMERY: I'm looking forward to hearing Professor Libecap. So I'll wait until after that.

LYMAN: Well, I'll just make one observation on that. Aquifers cover a huge geographical area, and they're constantly being replenished. You have the same problem you'd have with oil fields, with sharing.

So I don't know how you take a farm over a given aquifer, where the aquifer really stretches a thousand miles, and decide what's his water versus the other guy's. And I've been in the oil business long enough to know that making those trade-offs when you have adjacent fields is tough enough. But I think this would be a real nightmare.

ZAMUDA: It's an interesting issue, and it's not as though water's treated uniformly across this country. And the Mississippi is a great divide between water east of the Mississippi and how we treat that, and water rights to the west of the

Mississippi.

So I guess what we're really doing is setting the stage for the next panel. But it is kind of interesting. We have a model in place and it would be useful to analyze that and see how those two different models end up with different results and different problems.

Q: Thank you. **Peter Frumhoff** with the Union of Concerned Scientists. We just released a report titled "Freshwater Use by U.S. Power Plants," where we identified the temperature issues with water, not just discharging but power plants having to halt generation because of river sources being too hot.

In a lot of states, there are policies that say they can't intake the water when it reaches a certain temperature over ninety degrees Fahrenheit. Is there a policy, or is DOE looking into anything to help focus on this issue?

ZAMUDA: Well, two points, I guess, and one, I'll go back to an earlier point that was made about water withdrawal versus water consumption. And the only point I want to emphasize there is that even though the water consumption footprint is much smaller, if you don't have the water to withdraw, you're not operating.

So don't get blinded by small percentage numbers. We talk about three to four percent. If you don't have that forty to fifty percent of the water withdrawal, you're not generating electricity.

With regard to the issue that you raised, there are alternative ways. And I tried to mention some of them—alternative ways to provide steam electric generation without using water withdrawal, using dry or wet-dry hybrid systems. I think, John, you mentioned the challenge with that, is that it costs more.

So when we're talking about, in essence, free water—although water's not really free—but when we don't have a price on water, any of these technological adoptions that you pursue today have an added cost to that. So what DOE is trying to do is to look to those technologies and see what technological innovations can be pursued to drive that cost down. So that's the real issue. And you know, we've seen evidence in the last few years down in the Southeast where a lot of the plants were powering down because of the lack of water for cooling, on the verge of shutting down. It rained, thank goodness.

But keep your eyes on the state of Texas. I think we're recognizing that the state of Texas is perhaps a poster child for the future where already electricity generation is being scaled down because of the lack of water availability for cooling.

And the projection is, unless it starts raining, that spring in future years may pose additional challenges. So I think it's imperative that we look at some alternative technologies, either technologies for cooling or alternative technologies for which we can bring in nontraditional water sources to achieve the same ends.

Q: Sebastian Ehreiser from the Friedrich Ebert Foundation, a German political foundation here in Washington. I have a quick comment on Congressman Nussle's comments regarding habits and how we think about consumption of energy.

Through my time living in Germany, people think about these things much more carefully because energy is much more expensive, electricity and oil. So those "take for granted" notions are much less apparent in Germany, where we pay 30 cents a kilowatt-hour, $8 a gallon for gas.

Regarding the prices for dry cooling, regulation of steam generation and a possible price on carbon, John, that you mentioned, what kind of combination of these things would we need to reach grid parity with renewables?

You didn't mention wind or photovoltaic; that would address a lot of these problems. Which ones would have to happen and how quickly could this happen in order to reach grid parity?

LYMAN: Well, that's an interesting question, and I think it's a question that needs to be assessed more carefully. I would not like to just start throwing numbers out. One of the things that's happening is that the cost of renewables is changing, and the cost of other energy sources are also changing.

We've now had a complete wrinkle thrown into the U.S. system with the price of shale gas at $3 per Mcf, which has totally changed the ballgame. One big question is, if you start putting on not overburdens but realistic assumptions, regulations on asking operators to be more careful with the handling of their water, what's that going to do to the cost structures for shale gas?

And you also don't know what's going to happen with the greater use if, say forty percent of the coal plants retired because they're under retirement, they're old, they need to be replaced. They're not going to replace them, with the new regulations, and you end up using combined-cycle gas plants. That's going to raise gas prices. So I think it's too early to come out with concrete numbers on those trade-offs.

We know very well that if you want to do CCS and stuff like this, you've got to start talking about 80 cents, you know, $80 a ton on the carbon. But I don't know what that means until we work through all of the different things that are going to shift in the marketplace. There are a lot of shifts that are going to take place in the next few years, so I don't want to throw out numbers.

ZAMUDA: The only thing I'd add to that is that sometimes we look at a national adoption. And what one gains, I think it should come out of the presentations today, is that a lot of these decisions and a lot of cost will literally be a case-by-case determination. So take dry hybrid as just an example.

Dry hybrid systems are going to be much more efficient in a cooler environment than in a hotter environment, OK, just because the laws of thermodynamics, OK. So what that means is we probably need to not be looking at things from totally a national policy, national standard point of view, but have the flexibility to tailor that on a site-by-site basis, because that's where we're going to achieve the maximum effectiveness at the minimum cost.

LANE: I'm going to interject a good question that I've been holding from the beginning. I want to ask John and Craig too, I think. Both of you alluded to this notion that the areas with the most water stress are also the areas with the biggest population growth. But isn't this an example of the assumption that a lot of planners make, that people don't adjust to growing shortages and changing conditions?

In other words, if water stress is really growing that much in the Southwest and in California and Texas, are migration patterns really going to continue to add population to those areas, or don't we see locational patterns adjust to the new realities?

LYMAN: Well, I can answer that because the answer is you're absolutely right. The point you asked is, what are the challenges to the existing structure? And so the fact is that what we're talking about, you will cause shifts in people's habits.

People are going to be less enthusiastic about buying properties in Florida if they can't get water. It's a huge problem. People in Arizona right now are ignoring the problem. But pretty soon, Phoenix is going to be in a big problem. So how many more people want to migrate out there to the Sun Belt?

LANE: Well, yes, it's a problem with those areas, but it may be very advantageous for someplace else.

LYMAN: Yes, exactly. You will get long-term readjustment to the society.

LANE: Right.

LYMAN: And that's true with adaptation in general, whether there are people in Bangladesh who can't live in the floodplain anymore, so there will be migration.

ZAMUDA: I would add that when I was growing up, I had a Volkswagen and bought gas for something like 30 cents a gallon to put in that. Gas doesn't cost 30 cents a gallon anymore. And you can look at the adoption of some of the readily available technologies off the shelf today and use those to help reduce or eliminate this challenge.

The thing is, costs go up. But look at the price of gas and look at what you're paying today compared with what you were paying just three or four or five years ago. So how much can we absorb a price increase without having to resort to, "Well, maybe I'm not moving to Arizona"? So I'd say I think the jury is still out in terms of what really are the cost implications of moving to a twenty-first-century climate-resilient energy structure.

And are those costs that we're willing to accommodate without adjusting our behaviors, whether it's in terms of where we move, or the light bulbs we buy, or the cars we drive? I think that human beings being what they are, they are fairly flexible. I think there may be many situations where we find ourselves quite willing, not necessarily desirous but willing, to accept that added cost.

And if you look at the Southwest, the area that you mentioned, and you look at power plants coming online, recent power plants, what you see is use of technologies that aren't the norm for the nation. You see the use of wastewater treatment water for cooling at the Palo Verde nuclear power station. That's not a common example that you find.

But in that particular situation, given the circumstances, you needed a solution that would work, and that is working, evidently. And there are other examples like that across the country. But I think that kind of approach to recognizing the challenge and addressing it with available technology today and hoping for more advanced, more cost-effective technology tomorrow is

LANE: OK, we're out of time but two quick comments or questions?

Q: **Mike Kutsig** (ph) here. A couple of quick comments. I remember the comment by President Nixon about energy and about turning down the spotlight in the Commerce Department to save energy. And then we forgot about that after 1973 until 1979 when the price of gas went up again, and then we forgot about it again, and then we had SUVs which went nuts. And when the price of gas went up, we stopped with the SUVs.

We seem to have very short memories, number one. Number two, I think we are totally leaderless in this effort. There's no leadership from the White House or from other industries or from other people. Two comments, one of which I heard this morning, which was interesting. What the Congressman said this morning was that he took a long, hot shower. Those days may be over of taking long hot showers because the cost is high, number one.

Second point is a different example, is about the current fellow who is ahead in the Republican primaries. He is building an 11,000 square-foot house when people are losing their houses, being foreclosed, they have no jobs. This guy, I think who already has 10 or 12 mansions, is building another mansion, which is exactly against everything we think about energy.

One other point, I lived in China for six months. We overlooked a huge place like Central Park. At 10 o'clock at night, every light in that park went out. When I walk around here in Washington, every office building is lit up like a Christmas tree. It seems to me there's a matter of education, a real lack of education in this country as to the real cost of energy, of turning off electricity, of using less water and so on.

What do we do about that? And I think that's the major point because people are ignorant of the real cost, and maybe we should put a cost on water which is much higher than gasoline when you pay $1.79 for a bottle like that at CVS. Thank you.

LANE: Dr. Singer?

Q: **Fred Singer**: Just to clear up some misconceptions about the relation between climate change and water resources, two facts. Since the end of the last Little Ice Age two hundred years ago, the climate has warmed and I won't get into discussion about whether there was a human contribution or not. But when the ocean warms, you must get more evaporation. It means more humidity in the atmosphere which means more precipitation which means more freshwater.

Unfortunately, we cannot control, as yet, where the water comes down. But, there's no question that you must get more precipitation and more freshwater from a warming of the climate.

And the other fact comes from biology. More carbon dioxide means that plants will close their stomata, have less transpiration and therefore use less water and survive stresses better, both droughts and other kinds of stresses. So I come down on the fact that the global warming, no matter how it's caused, is good for water resources. That's important to keep in mind.

LANE: Go ahead, Craig.

ZAMUDA: Yes, it sounds like we've just created the need for an additional panel after the ones that were structured for this to address that topic. But I would just provide one example of where that may be true, but it still may be problematic.

So let's pretend we're in the Pacific Northwest, and we're basically saying annual precipitation levels are going to be the same or maybe they'll even increase with climate change.

Does that mean we don't have a problem with regard to water shortages for power generation?

LEE LANE, CRAIG ZAMUDA, JOHN LYMAN, AND W. DAVID MONTGOMERY

And I think the key is that the way the process works today is a lot of the water that's available for power generation in the summer where you're having those drought periods is being provided by that snow that was provided back there in the wintertime.

So the issue of temporal and spatial variability I think is key. The fact that you may be getting a lot of rain in the winter versus a lot of snow potentially is problematic, even though by volume it may be the same amount of moisture. If it's not around when you need it, you've got a problem.

And so I think that dismissing whether climate change is happening or not, or if it's happening, saying that it's not a problem because annual precipitation will be the same levels or may even increase, that's not a solution in and of itself. There are still problems out there with or without climate.

LANE: OK, thank you very much. I think we've provided a very good introduction for Gary and Sheila and the rest of the next panel. So with that, please join me in thanking this panel.

Panel Discussion II

Energy, Water, and Debt: Linked Problems, Common Solutions?

Moderator:
Kenneth Weinstein,
President and CEO,
Hudson Institute

Speakers:
Gary Libecap,
Bren School of Environmental Science and Management,
University of California, Santa Barbara

Jes Munk Hansen,
President,
Grundfos North America

Sheila Olmstead,
Tenured Fellow,
Resources for the Future

Kassia Yanosek,
Founding Principal,
Tana Energy Capital LLC

KENNETH WEINSTEIN: Well, we've had a very thoughtful and wide-ranging discussion in our first panel. And again, I want to reiterate my colleague Lee Lane's comments and thank our panelists, Deputy Assistant Secretary Craig Zamuda, David Montgomery, and John Lyman, for a very thoughtful discussion.

It's now my pleasure to welcome our second panel of prominent experts: Gary Libecap of the Bren School of Environmental Science and Management at the University of California, Santa Barbara; Sheila Olmstead, who has the title of Tenured Fellow at Resources for the Future; Jes Munk Hansen, the President of Grundfos North America; and Kassia Yanosek, the founding principal of Tana Energy Capital LLC.

I will actually dispense with the introductions since you have the bios, all of which are very impressive, in front of you.

GARY LIBECAP: Well, I'm delighted to be here. And we've had a lot of discussion about the energy-water nexus and various ways to economize on energy and so forth and economize on water. And we, to some degree, have been able to talk about energy prices. But remarkably, we cannot talk much about water prices. And that's what I want to talk about today—the limits of water markets, why they exist, and what the nature of water rights and water markets is today.

I think it is very important, frankly, in discussions about energy policy, or water policy, or climate change to put these into the institutional context in which the whole discussion or the research is taking place. And that just doesn't happen enough. And I think we got some sense of that this morning.

So it's really important to understand, who owns the water? Who can trade? Does surface water handle differently than groundwater? And if the answers to some of these things are unclear, well, why is that, especially given how important we think water is? So with that background, let me get started.

We've already heard about the growing pressure on water. We're not generating a lot more of it, but we're certainly generating a lot more demand. So the value of water is growing. In fact, one of the problems we have today, especially in the western U.S., is that water for a long time has just been cheap.

And so we haven't worried about it particularly. But it's not cheap anymore. And the question is how do we get the new reality, the new value reality presented in the form of prices, and how do we reallocate water in an effective and fast way?

So primarily, I'll move and discuss the nature of water rights in the West where much of the pressure that we're currently observing, and will observe play out, is taking place, and what we'll see is that water rights are very vague, and they're quite insecure. And what you'll also see, and I hope be surprised by, is just how limited and how localized water markets are. When I talk about water markets, I'm not talking about water within an urban area. But I'm talking about water exchanges from agriculture, where from sixty to eighty percent of the water is used, to growing urban demand, or to industrial demand, or to recreational demand, or even to water trades within a sector, say, among irrigators.

So currently, a lot of water, as we'll see, is locked into historical use. But without clear price signals and easy ways to move that water, it stays locked there. And so I want to talk about why that is. But that means we make decisions, then, about dry-powered energy generators without good ideas of the value of the water that we might be saving because it might be cheaper, frankly, if a lot of water is being used in low-value alfalfa flood irrigation. It might just be cheaper to move the water and use the old type of energy generation at that particular site, at least. So I'm going to talk also a little bit about the current nature of water market, the nature of water rights, and some of the regulatory constraints and how they vary across the states.

First of all, just to give you a sense of the current state of water markets in the West—and it's very hard to get data on this because there's no free trade, and these prices are not publically published in different places. But there are water brokers that operate in various parts of the West that try to move water from some uses to others.

And so, for example, in the area around Reno, just prior to the housing price collapse, you can get some idea of the marginal price of water. There it's over $17,000 per acre-foot, which is the unit of measure for water, as in sales from agriculture to urban. And the water prices for ag-to-ag trade—that is among farmers in the same region—these prices were about $1,500 on average.

So here you have water trading from ag to urban at about $17,000, and among farmers—these are sales—at about $1,500. We just don't normally see this in economics, to have adjacent resources selling at such remarkably different prices. And why is that? Part of it is a conveyance issue because you have to be able to move water from one place to the next. So a lot of it has to do with the regulatory constraints and the lack of clear property rights that exist. So we want to talk about what might be done there.

In Colorado, things are much better in many places. For example, in the South Platte near Denver, water from ag to urban was selling at a little over $6,000 an acre-foot, ag-to-ag sales about a little over $5,000. So it's closer, and that's because water rights in that area tend to be much clearer. In this case, they're shared in ditch companies. So you buy a share and that gives you access to water. And so therefore, the prices are closer and they are really reflecting opportunity cost, and also the conveyance structures are much better developed.

So you can get these kinds of narrow price data. To get a broader sense of the nature of water markets and how they operate—the nature of water prices—you really have to aggregate sales and lease data across time and across states. So you have to keep that caveat in mind to where you're really mixing a lot of water from a lot of different places across time and then putting it in constant dollars.

But nevertheless, it will still give you a good idea of the misallocation that exists with regard to water in the American West. So if you look at the median or mean prices for ag-to-urban leases (these are all leases, short-term, long-term, we've all converted them to comparable units) you can see here the median price is $74 to $190; ag-to-age leases, $19 to $56 and ag-to-urban sales, $295 to $437, ag-to-ag sales, much less, again.

The point you want to take from this is that water is oftentimes much more valuable if it's moved out of agriculture. Now, I'm not talking about moving all water out of all agriculture, but marginal water out of agriculture and shifting it to use in industry, energy production, and in urban use.

And so there are all sorts of incentives or indications that we don't do that effectively. This is a dataset that we put together for twelve western states through 2008. And you can see generally the top broken line reflects all trades, so there's more activity taking place. But even so, we're not talking about thousands of transactions. But we're talking about hundreds of transactions annually across an entire part of the country. And generally speaking, ag-to-urban prices are reflecting higher values in urban use than they are if water stays in agriculture.

Across the states, water trading varies dramatically. The most active states are Colorado Arizona, Texas, and California. But within them it's quite different. Within Colorado—and different parts of Colorado—there is a very active market structure moving water in small amounts from ag to urban just routinely, not controversial. In Arizona, there is a somewhat more limited water market. But in California, as in so many other ways, even though I live there, it's quite different. There almost all water is just traded in short-term leases, and that's because it's really hard to move water from ag to urban.

Now, that doesn't mean that San Diego wouldn't like more water, or Los Angeles wouldn't like more water, or San Francisco wouldn't like more water, and that farmers in the San Joaquin or Sacramento or Imperial Valley wouldn't like to sell them more water. It's just very difficult for them to do so, and I'll talk about that.

There are some trades, but some of them take a great deal of time—twenty years or more—to put into place. So in the meantime, you end up adopting a lot of alternative measures that are costly and perhaps not that efficient in the long run—from low-flush toilets to all sorts of other things that frankly might be dealt with more effectively by just reallocating water from agriculture to urban use.

Let's look first off at the nature of water rights to try to get an idea why these markets are so limited, why trades oftentimes are so hard, and why this market is still local, and then think about what we might do about them. First off, in the West, water rights are assigned differently than they are in the East. The East is a riparian water rights system where adjacent landowners own the surface waters at least.

In the West, it's a priority system that developed historically out of mining and then later agriculture because often the mines and the farms were not where the water was. And so they would claim the water and then move it to the location of economic activity. The first person to claim it claimed a certain amount of water and has the highest priority, and the second person the next-lowest priority, and so forth.

What that means, though, is that it assigns a fixed amount of water to a variable flow and the West being the West, where droughts are frequent, the amount of surface water that's available varies dramatically from year to year, and the highest priority claimant gets first claim on the water. And it could be the case that the low-priority claimant won't have any water.

So what that means is we have to have some kind of exchange between them, and they're oftentimes very informal exchanges that take place. But what this also does, though, for water markets, if the high-priority water rights owner decides to sell some water to somebody else out of basin, then that water is not going to be available to the junior rights holder when there is a drought. They can't exchange it, or sometimes as well not all of the water will be consumed by the high priority rights holder, and as a consequence that residual water is then used by the lower-priority rights holder.

But if all that water is pulled out of basin, it's not there. So there's a potential third party effect. And that leads to a fair amount of litigation or resistance to water trade. Another problem with any water trade is that—particularly in California, but in other western states as well—there is a very wide range of standing for people to claim potential harm from any water trade.

And so if you need to move water in a hurry, or you're a developer and you want to add a subdivision in San Diego and you need to access water, you suddenly are hit with a regulatory process that can take years and years and years or a litigation process that can take years and years because of the wide range of people who can claim that they might be harmed.

And so it's the structure of the no-harm requirement, as I'll point to in a moment, that also slows down the process. So there are lots of areas in which refinement is necessary in order to smooth water markets. Now, I'm talking about surface water. But groundwater is already of increased importance. Groundwater in California supplies about thirty percent of the state's use, and I'm going to show you a slide in a moment. Nevertheless, most of the groundwater basins in California are open-access resources.

That means everybody who's got land above that groundwater resource has the right to extract a reasonable amount—however that's defined—of water from that basin. And so what that does is lead to the classic race to the commons or the tragedy of the commons potentially. I won't have time, but water rights are defined somewhat differently in Northern Colorado, and that's the place where trades work best. But I actually do not think we can redefine water rights. You just can't change ownership to a valuable resource like that with all the uncertainties that that imposes. So I think we have to look at other ways to use the existing institutional structure and make it work more effectively.

Here is a picture of groundwater basins in California, and only the red ones actually have the rights to them well-defined. Naturally, they're in Southern California where water is most valuable and there's been more subsidence and more key water intrusion actually from overdraft.

So it's not surprising that's where water rights are firmest. But nevertheless, it gives you an idea of just how much work remains to be done to firm up water rights to groundwater basins. And it actually ought to be easier than oil because water typically doesn't flow so smoothly across the basin. So in some cases it varies, but it oftentimes it can be more stationary within the hydrological system and so it might be easier, frankly, to define water rights. Anyway, it's certainly possible—and in those twenty-two groundwater districts it has been done—there's a local water master that monitors wells and can withdraw from those wells, and there's an active water market within each of those groundwater basins, transferring water across users in those basins.

Here then are some of the regulatory constraints that lead to those price differences that I indicated earlier and explain why water markets are so narrow. Every state requires that water be put to beneficial use. But what does beneficial use mean? Well, it's politically determined, and so there are a list of preferential uses and those only periodically change.

All water can be used or transferred only if it doesn't impose third-party harm. That's a real issue. I'm not denying that. But nevertheless, that needs to be made much more precise and much more concrete so that it isn't an open-ended barrier to water trade. Moreover, multiple agencies are involved in every water transaction. And this is especially true in California where the water may be held within an irrigation district and the individual farmer's ownership rights may not be that clear, but even if it all gets through that process, then there are multiple state agencies and county agencies that have to approve every trade.

And so, as a consequence, you can see differential incentives and all sorts of potentials to slow this down. As a result, water is often a common, not a private, resource despite the fact that its value is increasing. And then we can layer on top of all of this the public trust doctrine, which argues that some resources are so inherently public they should not be privatized.

The public trust doctrine has been expanded into water in the West, and in California particularly, to mandate a greater state and political role in regulating water. And this just flows exactly in the opposite direction of where most other open-access resources are moving. In most cases, fisheries are moving toward rights-based systems because of the high cost and the ineffectiveness of the old regulatory regime. And we see with cap and trade and with emission allocation with the sulfur dioxide regulations, the Clean Air Act, also a market mechanism to avoid high regulatory costs. But with the public press doctrine we're moving exactly in the other direction. So that also raises costs.

To conclude, water is an increasingly valuable resource. It is right at the heart, naturally, of the energy-water nexus. But, in order to address this effectively and get water prices—so that we actually know the value of the water that we're trying to save, that we have some incentives to conserve water, that we have incentives to invest in the water stock, and incentives to reallocate water—we have to firm up water rights and have more water markets.

So what are some ways forward? Well, one thing to do is to clarify water rights. This can either be through a judicial or a legislative process. It has to be done, especially within irrigation districts. In some irrigation districts, the entire community gets to vote on whether or not water can be moved. So you can imagine how complex that is.

But even with the Bureau of Reclamation, which supplies much of the water in the American West, water rights are not clear. Is it owned by the Bureau of Reclamation? Is it owned by irrigation districts? Is it owned by the farmers within the district? And who has a veto on any potential trade? And it's not common across the Bureau of Reclamation.

We ought to streamline the trading options so that we have more trades within basins, but importantly across basins, because we want to move water from agricultural areas to urban areas—where most of the people are, where most of the manufacturing, where most of the economic activity is taking place.

And then, finally, there has been the importance of refining water rights to groundwater, and some states have actually done this. Arizona actually is the leader, in certain areas of the state, in defining groundwater and allowing for certain kinds of groundwater trade. And so we get groundwater prices and greater incentives to conserve on that resource. But it's not the case in most places in California.

And finally, we ought to find mechanisms for trade across states. There are virtually no private trades of water across state lines and very few trades of any type across state lines. So, you have one state with lots of water, or at least excess water, and another state desperately in need of water—and to think of Nevada versus Arizona—we ought to find a mechanism to move water more effectively between those two states. Thank you.

WEINSTEIN: Thank you very much, Gary. That was fascinating.

SHEILA OLMSTEAD: So thanks very much to Lee and to Ken.

Usually I would start a presentation of this type by talking about water pricing first—and I am going to do that—and then I would talk about water markets. But I actually learned most of what I know about water markets from Gary's work, and he certainly covered that today. So I'm just going to briefly touch on how I think that fits into the whole picture, without describing anything about what's going on, since he's covered that so well. And then regulation will be the third piece in this "solutions" discussion that I'll be talking about today.

First, I wanted to take a little look at trends in U.S. water withdrawals by use. This is data from the U.S. Geological Survey, which in the United States does a pretty good job of tracking water and various uses in different parts of the country. And I wanted to do this because I want to highlight some good news, actually, that if you look historically at U.S. water withdrawals for various types of uses—and I'll take thermoelectric power generation as an example here—what you actually see over time is that we've become much more efficient in the way that we use water and the extent to which we use water.

So the trend of total withdrawals is in the blue line at the very top of the graph, and you can see that, for a long time, total withdrawals were going up. The country is growing, and the economy is growing. And even as that continued to happen, post-1980 or so—what we see is that trend of total withdrawals leveling off very much.

And in fact, if you take individual uses, taking thermoelectric power—this is withdrawals, not consumptive use, as people previously have pointed out that they're very different—but thermoelectric power withdrawals in this graph represent almost half of total withdrawals. And what you see is that we were using about 63 gallons of water per kilowatt-hour to generate electricity in 1950. And now we're down, in 2005—the most recent year for which the data are available in this graph—to about 23 gallons per kilowatt-hour of electricity.

So that's a big change, and it's something that we often don't think about, the fact that we've actually become much more efficient in our water consumption habits. And you would see this in urban settings as well. To some extent you see that in agriculture as well, although as Gary said, there's a lot more room—comparing across sectors, perhaps—to continue in that fashion in the agricultural sector.

But I want to also use this to talk about the fact that the way that we manage water resources is very, very different from the way we manage energy resources. And this has already come up as a theme. I want you to think about what would happen if it was a particularly cold winter in New

England. Energy use is going up because people are using energy for heating. The mayor of Boston comes to the citizens of Boston and says, we're going to have a heating mandate to deal with the fact that energy use is going up, and it's a time when energy supplies are scarce and so the maximum temperature at which you can set your home thermostat is going to be 68 degrees Fahrenheit. And we're going to enforce that. Or during a particularly hot summer in D.C., we would say, everyone can use their air conditioning in Washington; but if your home address ends in an odd number it will be on Monday, Wednesday and Friday, and if it ends in an even number, it will be on Tuesday and Thursday.

And it seems a little bit ridiculous when I say that, but in fact that is exactly what we do when water is in scarce supply in urban settings. The price doesn't go up, unlike in energy settings. The price doesn't go up; it doesn't reduce demand in response. Suppliers and consumers don't really have a sense, often, through the price, which communicates in other markets such important information about the scarcity of a resource and its value in use. We don't have that signal necessarily for water consumption. And so we see, as a result, some perverse results in water markets themselves, many of which Gary pointed to in his presentation.

So first what I'm going to talk about today is, I'll show you a little bit of simple data that looks at this decoupling of water prices from water scarcity, both spatially and intertemporally or over time. I'll show you some evidence that prices actually can and have been used to reduce water consumption during periods of scarcity. Gary has also already shown us some evidence that water markets themselves across sectors can move water from low-valued or lower-valued to higher-valued uses.

And then of course I'll come to the end of the discussion, where I talk a little bit about regulation and the fact that pricing and markets aren't, in and of themselves, panaceas, and that regulation will play some important roles, especially when it comes to water quality. Gary touched on that a little bit when he talked about third-party impacts from water marketing and the need to think about that carefully, in order not to arrive at just more inefficient outcomes from what we already have seen.

So just to get to this question of the decoupling of water prices from scarcity. This is a graph from Circle of Blue, which is a website that I think does a really nice job, often, of picturing information about water resources. What it's showing us is the average monthly bill for a family of four in five different cities. So the cities from left to right on the graph are Las Vegas, Phoenix, Boston, Milwaukee, and Santa Fe.

Then the black, to bright orange, to light orange graph is showing us the average monthly water bill for a family of four using 50 and then 100 and then 150 gallons per day on average. The average for the United States is about a hundred, so you want to think of the height of that orange bar as being about the average. And then the green bar represents average daily per capita residential consumption in that city, in gallons. And the blue bar gives us average annual precipitation or some sense of the supply of regional water in that city.

If prices were giving effective market signals in these markets, what you would see is in places where you tend to have somewhat high demand, a high green bar, and/or low supply, a low blue bar, you'd see relatively high prices—trying to bring those bars a little bit more into accordance with each other.

And in fact, if you start on the left-hand side and you look at the cities of Las Vegas and Phoenix, what you see is really high demand, really low supply—and the prices, compared to the prices toward the left side—or toward the right side of the graph, in Boston or in Santa Fe—are actually quite low, right, for that situation.

Economists including myself spent a lot of time making all kinds of fancy models, statistical models of the relationship between price and demand and climate and all these other important things that drive water consumption. Those are important, to get precise estimates of the relationships between those variables, but water markets and water allocation can be so perverse, as a result of this disconnect between prices and demand and scarcity, that the basic message of those models, you don't need the fancy models for. It pops out just when you look at simple graphs like this.

And if you go all the way to the right, you see an opposite case. In Santa Fe, another place where you have relatively low supply and somewhat high demand, you actually see prices reflecting the discord between the demand and supply situation. So it's not wrong everywhere, but there are plenty of places in the country where they don't get that pricing right. My first message is to think spatially about scarcity and think about aligning prices with scarcity a little better than we do now.

The second message is that even if we stay in this setting that's within one urban market, it's also true that, even if prices on average might be right, we still have a lack of flexibility of letting prices match scarcity over time. For example, most cities in the world have some part of the year where water is more scarce than other times. Many of the largest cities in the world have that problem; certainly we have that problem in the arid western cities in the United States.

The data that I'm showing you are actually from a paper by an economist named Hugh Sibly, who's an Australian economist. And this is looking at some different trends in the city of Sydney. The first thing I want you to look at is the storage trend, represented by the squares. And what you see there is not at all atypical of an arid region.

But you have a lot of variation in that storage, in that some of that is seasonal, but certainly also you may have either random or sometimes cyclical or cyclical-plus-random cycles in the availability of water resources. In Sydney, they were experiencing a pretty significant drought; so you see that storage peak right around 1998-99, and then come way down, down, down toward 2004–05, which is at the end.

And then what you have is per capita residential demand; that's the triangle series. That's also kind of going up and down. That's the solid line connecting the triangles. And again, not at all atypical for a dry city, what you see is that times when the storage is relatively high or rain is coming or supply is relatively high, the demand is relatively low, because people aren't watering outside, or they're taking shorter showers, or whatever they're doing that's using less water. And the opposite is also true. So those two lines would tend to move inversely with each other—the storage would peak and demand will fall, and then demand will peak when storage falls, and so on.

And if the price were providing a good signal as to how households and firms should react to the problem of scarcity, you would see the price trying to track a little closer to the shortage problem. And in fact what you see here the price is kind of moving around in random fashion rather than closely tracking scarcity.

So it's not really giving us a clear signal about how—from year to year or even from season to season within a year—supply is changing. It is not telling us how valuable the water resource is as you're turning on your tap or your sprinkler. I think if we were to correct that, we would see a lot less water consumed in urban settings in these dry areas.

If you actually believe that that's true, then the next question you have to ask is: how does water demand respond to changes in price? And often, when you talk with folks who manage water utilities—who are trained in engineering and other fields outside of economics—they will tell you that, in fact, it doesn't respond very well to prices; that people aren't paying enough attention to prices to really make much of a difference.

But when you go to the data, and you actually look at the studies that have been done—some of them by myself and colleagues—you can find papers going back to the 1960s that do a nice, rigorous job of looking at this. On average, if you were to increase the price in the residential sector by ten percent, what you would see in the short run is about a three to four percent decrease in demand. And in the long run, when households and firms have the opportunity to switch out their water-consuming technologies or plant something different in their yard or so on, you would see a much bigger response again on the order of double that, so about six to seven percent in the long run.

In the industrial sector, we actually have a lot less information. There are many fewer studies of the industrial sector, but there's a nice study of fifty-one different French industrial sectors that was done in 2003. And if you look, of course, it's different across sectors, and it would be different in different places and at points in time. But, on average, a ten percent increase in the price of water in the industrial sector reduces demand by one to eight percent in the short run, depending on the industry that you're talking about.

So you would say, well, are those big reactions or are those small reactions? They are in the range of what economists would call inelastic demand—inelastic meaning that, for every one percent increase in price, demand decreases by less than one percent. But I think there's also a semantic issue here, in that folks that do manage water often interpret that term "inelastic," as meaning unresponsive to price. And in fact that's not the case.

For utilities it's somewhat good news, actually, that price is in the inelastic range—elasticity is in the inelastic range. And that's because, when you increase the price and the response is less than a one percent—or one percent change—you actually increase your total revenues. In comparison, what would happen if you're on the other side of that, and the price responses are elastic, and then you'd have actually a one percent price increase that would decrease demand by more than one percent, and then you have a revenue shortfall.

So that's something that we can talk about at greater length, perhaps in the Q&A if people are interested in that. But I always find it interesting, talking with folks who worry about managing water and trying to deal with that misconception of what "inelastic demand" means.

Something else to think about is, the residential estimates at least are actually quite close to what we see for electricity demand. If you're going to insist that water demand is not responsive to price changes, then you would have to say the same thing about electricity demand. And we know, in fact, that that's not the case. I would leave you with the message that we know that about both of those subjects. It's simply less well-known for water.

There's also the question in industrial settings—and this is especially true for energy generation and for cooling in particular—that lots of firms are using self-supplied, raw water. We know a lot less, naturally, about how much water is used for those purposes, how responsive those firms would be if we implemented a price of some kind.

There is actually some nice evidence, from some studies in Canada, suggesting that if you were to implement some kind of two-part pricing scheme for the folks withdrawing raw water and using that in cooling or other industrial processes, you could actually—just like we see in the industrial sector where people are already paying for water—you could actually reduce demand by some significant percentage. Again, we can talk some more about those studies later on.

One thing I would want to say, though, is that the response to pricing structures like that, when you're introducing them, is likely to be pretty lumpy. Unlike the residential sector—where there are lots different things that one can do to reduce one's water consumption, both in the short run and the long run—some of those things are kind of lumpy, like replacing an old appliance, where you'd have a sudden bump downward in your water consumption, and some of them are more continuous, like turning the water down or off when you're brushing your teeth, where you would see small changes in response to prices.

I think, when we're talking about industry—and in particular when we're talking about cooling for thermoelectric processes—I think we're talking about something that's actually much more on the lumpy side. So, for example, in the simulations that were done that make this suggestion of one to eight percent decrease in price in response to introducing pricing, what you would see is that firms might, for example, move—at some point, if the price increase were significant enough—from once-through cooling to recycling. And there they would get a huge bump downward in their water consumption.

But then afterward, there's not a whole lot that they can do once the new technology is in place. So if the price were to continue to go up, you might actually see less responsiveness over time than you might have modeled early on, if you hadn't taken into account the sort of discreteness of that choice that they have to make. But it's certainly something that we need to know more about, and something that we could model and be much more careful in thinking about than we have been.

So with regard to water marketing—in the sense that what I'm talking about with water pricing is often just within a sector, within a particular city, for urban use, or within an agricultural irrigation district or within some other entity that's selling water at some price—you need to get the price right.

A lot of what Gary was talking about is these cross-sector questions. Those types of efficiency gains from this cross-sector reallocation of water might be even more important—or are likely to be even more important—than these within-sector results that I'm talking about with pricing. I wanted to point that out as another important tool that's already been covered.

And then finally, prices and markets can't do everything. So then we need to have a conversation about whether there's a role for regulation and what that role is, and the fact that some regulation is simply better than others in economic terms. I wanted to harp on that a little bit, because it's my job as an environmental economist to talk about cost-effective regulation.

The reason that I say that prices and markets can't do everything is that there will always be externalities to electricity production and consumption. I'll make a list of those in just a minute. If we were just to leave things up to the market, we would not have efficient outcomes without some form of regulation. Some examples of that, if you're talking about damming water or diverting water from the stream and so on—any kinds of withdrawals can alter downstream hydrological regimes. So you can have these third-party impacts that Gary mentioned when he was talking about water marketing.

Also, the processes of fuel extraction and production—like lots of industrial processes—generate pollution. That includes everything from coal and gas and oil development to fuel transport to inadequate waste-water storage and treatment from those processes. And then, of course, even when you move away from energy supply to electricity generation, those processes themselves generate pollution as well. These are just classic externalities that often need to be addressed through regulation.

These impacts, both in terms of water quantity and in terms of water quality, have measurable economic value. So it is at least in theory feasible to figure out what the value of water is in various uses, and think about what those different side payments might be between parties engaging in a trade and the third parties that may be affected by that, and so on.

So some examples of that—if you look at end-stream values, some economists have estimated these, mostly for the western United States because this is where water resources are predominately scarce in the United States. And, you know, the recreational uses have felt pinched in competing with agricultural uses; primarily that tends to be the kind of marginal use in most of these basins.

When people have looked at the value of these recreational uses, like fishing and water fowl watching and hunting and so on, they tend to often compete in some of these very arid regions pretty well with some of the other uses in those basins, particularly with agriculture, because, in large part, of the fact that prices have been so low or nonexistent for agricultural water consumption, so on the margin, you see a lot of these low-valued uses that are just not competing very well with the higher-valued recreation and other uses. There are other examples that people have looked at for California, San Joaquin Valley and so on. And again, we can talk more about these if people have questions.

So in my view, one thing that would be very interesting would be to know for different parts of the country what those values are, and how they compare with each other. And unfortunately, there's not a lot of recent, large-scale work on this, even within single basins. I went back to a 1996 paper by Ken Frederick, who was a fellow at RFF, where I'm currently working. So you have to go back a good ten or fifteen years to find these kinds of estimates.

But what these guys did is they looked at major water types of uses: end-stream uses—waste disposal, recreation, fish and wildlife habitat, navigation and hydropower. And then there are, of course, the diverted uses as well at the bottom: irrigation, industrial processing, thermoelectric power and domestic or urban sort residential consumption.

The first column tells us what the average estimate of the marginal value in dollars per acre-foot was back in 1996, looking at all the studies that have been done on that particular use to that date. The number of values in the far right-hand column tells you the number of studies that they summarized to get to this average—median, minimum, and maximum values.

And you can see for some of them it's a very small number of values, and you wouldn't want to count too highly on the average, and for others it's a larger number of values. What pops out at this is some of those end-stream uses—like recreation, fish and wildlife habitat—actually compete reasonably well with some of the withdrawn uses. That tends to be even more true over time as the water has gotten scarcer and scarcer.

If you look just at the East versus the West, for example, the ratio of end-stream to withdrawn uses in the West, at the time, was about 0.7. The marginal value—that last acre foot—it's much, much lower in the East, where water is more plentiful, and of course these uses aren't competing quite as heavily.

The water quality impacts or externalities that I talked about also have measurable economic value. There's huge literature on this. I'm not going to get into it. I think just to summarize I'll say that there's a very well-known study by Carson and Mitchell in 1993 that estimated the annual benefits to the United States just from the Clean Water Act of 1972 and its amendments, and that was about $29.2 billion in 1990 dollars per year, so if we convert that to 2010 dollars, of course it sounds bigger.

And then, again, there are lots of localized studies suggesting significant economic benefits from protecting water quality as well. If you're talking about drinking water, which often we're not talking about in the United States because we have a very good and well-regulated drinking water system, but if you move to other country settings where you're competing with withdrawal of water and using it for drinking purposes, then you're talking about very, very large values. If you're going to try to compete with those kinds of values it's going to be pretty tough.

And so what's the problem with this? Well, we certainly have had energy supply and electricity generation and so on in the country for a long time, and some of these externalities have been around for a long time. So I'm not going to argue that we've fully internalized the externalities to energy supply or energy consumption in the status quo.

But if we look to the future, what we have to think about is the movement toward the extraction and consumption of more unconventional fossil fuels, and a lot of the attention surrounding those—for better or for worse—has focused on effects on water resources. So this energy/water problem seems to be somewhat heightened when start talking about the exploitation of unconventional fossil fuels.

We have a project right now at RFF on shale gas, where we're trying to look at these intersections between shale gas development, this incredibly important resource for future U.S. energy policy, and what the externalities may be, and what the risks might be, so that we can think about how to quantify some of those trade-offs and the benefits and costs of either voluntarily changing firm practices or potentially thinking about some kind of local, state or federal regulation to deal with these problems.

If you look at the recent U.S. boom in unconventional fossil fuel extraction, it tends to be focused in arid regions. The Marcellus shale is an exception to that—that's come up once or twice today. That's Pennsylvania and New York, Ohio, and West Virginia.

But if you look to most of the real boom-town activity that's going on, it's in Texas, the Southwest, the Rocky Mountain states, and the upper Great Plains. These are regions that historically, of course, have been very arid, that climate change would anticipate some increasing concerns about aridity. Either that comes from seasonal changes or changes in precipitation itself.

In addition, you pair that with the problem that the raw water that's used as an input to these extraction processes, and used in very large quantities, is generally withdrawn free of charge, and as an economist you see the train wreck coming. If we are worried about scarcity, then we have to be worried about prices. And if we're not, then we've simply laid a trap for ourselves that's going to be very difficult to get out of once all these firms locate in these places with their technologies that are very expensive to switch, and so on.

Another thing that we have to be concerned about is that what captures public attention. Shale gas may have benefits for climate change. But I think, unfortunately, what captures public attention much more so than the potential benefits for climate change are the potential costs to their local water resources—ground water or surface water.

There are some examples of that: at tailing ponds or tar sands extraction or production in Alberta. These cause very significant water quality concerns. A lot of the concerns over the pipeline had to do with water quality: the shale gas, whether you liked it or not, the award-nominated documentary "Gasland" which focused very much on ground water and surface water impacts of shale gas development, and then the Deep Water Horizon event.

So all of these are now stacking up public concerns with respect to water resources and unconventional fossil fuels. I think that we simply can't get around finding a development process that's going to address some of these concerns, or at least increase what we know about the science on these concerns. So that said, as regulation develops at the state and federal level, and it seems to be in the process of doing that, we have to keep in mind that smart, cost-effective regulation is going to harness market forces to correct these market failures.

Gary mentioned the sulfur dioxide trading program. I'm sad to say that is essentially defunct now. That's been destroyed by a variety of regulatory changes at the federal level, but it is a classic example of what was once a well-functioning market for emissions rights that saved on the order of a billion or 1½ billion dollars per year while it was functioning, relative to the technology standard that was the most likely next choice that EPA could have made to reduce emission from coal-fired power plants back in 1990.

These kinds of marketplace regulations, taxes, tradable permit systems, are cost effective. There's so much evidence for this, relative to technology standards and even performance standards that have some flexibility, but that don't allow enough flexibility in terms of the ways that firms can meet those goals.

Some ways of thinking about this in the water and energy context would be to move toward long-run marginal cost pricing for water; to inject some of these market signals that seem to be lacking within markets and across markets, as Gary pointed out earlier; to expand water marketing; to define property rights that recognize public goods and these third-party impacts; to get past this impasse of either having a reasonably well-functioning market or having one that's completely frozen up over the externality issues. We think that harms everyone in the long run, not to have some happy medium between those two things.

And then certainly, as we're talking about ambient water quality regulations, especially if they address specific energy concerns like unconventional fossil fuel extraction, allowing as much flexibility as possible from offsets to outright trading. And the EPA has estimates of the potential economic benefits of moving to water quality trading, and incorporating that to a greater extent within its compliance mechanisms, or the firms and other regulated entities' compliance mechanisms.

And it's huge. Back in 2004 they estimated something on the order of about a billion dollars in savings per year for enhanced water quality trading. So moving in that direction, I think, can be also extremely fruitful.

So in conclusion, I'd like to see the injection of more market incentives into the water sector that certainly can help ensure sustainability of resources. It's something that's come up several times today. Realizing that pricing in markets, while they're critical pieces of the picture and have to come almost first, they're not panaceas; that there's still an important role for regulation, especially with respect to water quality. Energy production is one of lots of important social objectives for water resources, and we have to recognize that other social objectives have high social values, some of which will complete in certain regions and at points in time with energy production, and that ought to be recognized by water rights systems. And then finally, we could try to take into account the opportunity cost of using water for energy production. Markets would do that, and regulations.

Thank you.

WEINSTEIN: Thank you. We've had two really extraordinary presentations so far. First we heard from Gary, who talked about the limits of water markets, due in part to some of the initial regulations that took place governing water. And then, from Sheila, we've heard that there is, in fact, some elasticity of demand, but prices and markets aren't everything. And smarter regulation can undo some of the damages that occurred—or some of the problems that occurred with the original way that the water markets were limited—and could deal with externalities, including social values.

Now we have the honor of hearing from Jes Munk Hansen of Grundfos about how technology, I suspect, will play a role in dealing with the water and energy issues.

JES MUNK HANSEN: I would like to start, though, by thanking the Hudson Institute for establishing this platform for discussion on a very relevant subject, and, as we could see this morning, also at times a quite complex discussion. The previous speakers set the stage very well for this very strong link between the nexus of water and energy.

We're very happy to sponsor this event today. We do that because we have to learn. And I have learned a lot already this morning. We are in the industry. And of course, we are interested, as a player in the water industry, to understand how we can help and be part of the solutions to these issues.

Let me give you just a few words about Grundfos. Grundfos is globally a $4 billion company. And we are active in the water and energy arena. Our main products are pumps. We also make motors. And what is very important to us is that we make controls, software, and electronics to actually control these pumps. I dare to say here that we're seen as the technology leader, and most of our activities are within the green tech sector.

Here in the United States specifically we are today at 2,000 employees. And we develop products specifically for some of the issues we heard about today here in the United States. We develop them here in the United Sates, and we also manufacture these products in the United States and of course also sell and service them here in the United States.

I would like to talk about technology. I have basically three points I, as a developer and manufacturer of equipment for the water industry, would like to present. First of all, I think there's a lot of good news also in these complex issues. I think there are a lot of technologies already available. Some of the speakers pointed that out. There are technologies we can apply already today. And then also some of the speakers and comments around here were also about education and about change in behavior, and how we use these. I'll come back to that, of course.

I do also want to speak two words more, energy labeling, labeling products, and making it clearer to the user how efficient their equipment is, both when it comes to water and energy. And when I'm talking about uses, I won't just talk about the end-user and residential; I'll also talk about industry and, of course, also municipal.

Together with these labeling systems, I also do believe we need to set some absolute minimum requirements for the equipment that we implement.

And finally—and I think that is the best news here—I think there is a real opportunity here for a win-win-win situation, both for consumers, post-industrials, and their society.

Let me start out with the technology side. As I said, there are a lot of technologies available throughout the industry already today that can address many of the issues we have seen and heard about today. We heard about how demand is going up, both for energy and water, and that will continue for the next few years.

And I think it's clear to every one of us that we cannot—on the supply side—simply just drill thousands of more wells or put in thousands of miles of pipes or establish thousands of new power plants. That is not realistic. It's particularly not realistic in the economic environment we are in today.

We need to develop and install new technologies, more efficient technologies that utilize existing resources much better.

We—on the demand side—can dramatically reduce it, our consumption of these resources. And I believe also we are doing that, can secure prosperity and growth.

When I say technology exists, I think it's also important to stress that I believe that technology exists that is feasible. It's both technologically feasible, and I believe it's economically feasible to implement. And let me take a few cases from the industry I know best, and that is the pump industry.

We in Grundfos developed some technologies we call AUTOADAPT. And why have we done that? If we took a little walk here through this building and walked down to the mechanical room, I'm sure we would find—first of all, I know we would find a lot of pumps—much more than you think. But we would find very old equipment. That is generally the case, that the installed equipment is old. It is equipment and technologies from the '50s, sometimes from the '40s.

And much of that equipment is not only old and inefficient; even worse, it basically runs all the time. It's not regulated equipment. Imagine this morning, when you took your car to work, if you came out to the garage and the engine in your car was already running, you jumped in the car and you navigated traffic all the way down here by applying more or less pressure to the brake, and then you parked the car outside here running.

That is unfortunately what happens with much of the equipment in the water industry. As simple as it sounds, studies have shown that equipment—pumps, mainly—need to run only five percent at full capacity. But unfortunately, many of these that I look at, they run all the time.

So we have developed a technology we call AUTOADAPT technology. And it's basically sensors and software that measure throughout a building what specific needs are—for water, for cooling, for heating—and, in a relatively simple way, feed back to the pumps and ensure that the pumps and the heating and cooling systems run only to the point that they're needed. It sounds simple, and frankly it is.

By doing that in buildings like the one we are in today and residential buildings, we can save up to sixty percent on energy consumption by buying existing technology. You can—at least sometimes—reach these solutions in ways that are relatively simple.

I'd like to explain another case that is more from the municipal arena. It's somewhat similar, but yet different. We didn't hear about it today, but many municipalities struggle with the fact that most of the water that gets pumped into a municipal system is lost through the distribution. In some cases it's up to fifty percent of the clean water that gets into a system gets lost before it ever makes the tap. And it is because of very, very old infrastructure we have in our cities today, that pipes are leaking and equipment is old.

And again we have made these systems smarter in the water industry by applying sensors, software, and controls. Instead of running and pressurizing a municipal system all the time at full capacity, we go in and regulate what is actually needed. If it's night, you don't need too much water. If it's afternoon, it's different than in the morning. A relatively simple concept; of course it takes some technology, and of course it takes some willingness to implement. But the solutions exist, and they have already proven their viability.

What I liked about this morning's presentations was that I do feel optimistic as a man, a certain consensus, at least at the end of describing the challenges we are in front of. But I do also feel and sense that there is a common understanding across academia, politicians, and industry that we need to act now.

And that's why I would like to suggest two measures I think we should work more with. They can solve a lot of the challenges we have. And it is, first and foremost, to simply set some more requirements for the equipment installed throughout our infrastructure. We need to lift the water industry to the next level. There has not been enough innovation and investment in the water industry. We have seen that it works. I still need to see the proof, but from an academic point of view, we've seen that it works at least last year in the United States—the new standards for electric motors we implemented, the new NEMA standards. And arguably, we now, in the United States, have the highest standard motor efficiencies in the world. It will be interesting to follow—I'm sure some of the academics in the United States will follow and see how the dynamics there work out. But it can be done. And again, I point to the fact that the technology does exist.

Maybe more important than minimum requirements to equipment is more transparency. That's why I call for more labeling systems, more education. Much of the issues we have, and I think there were some people pointing it out earlier, are related to change of behavior. It's pretty difficult, as a consumer today, to make the right choice, because there's simply no visibility on how efficient the equipment is. And I must say, I hear often that when we say consumers, then I think most think about those who own a house. But I can tell you the challenges, when I meet with engineers from municipalities, from breweries, from hotels, there's a huge gap in data, in understanding and education of energy efficiency and water. It is not only we private homeowners who need to learn. It's definitely also the professional arena that needs help. I think a labeling system of some kind, to get more visibility and transparency, could drive a lot of it.

So we need to lift the industry—the entire water industry, I'm talking about here—to new standards, to new levels of innovation. And I said up front, I'm actually quite optimistic and positive as you can hear here. I think there are several opportunities for a win-win-win situation. I think there are great wins here for homeowners and for owners of hotels and industries, because there are significant savings in electricity, and there are significant savings also in water. I think we in industry have a fantastic opportunity to step up and take leadership, to develop new products to innovate. And then I think there's a fantastic win situation for society by reducing the consumption of resources—and if not reducing them—at least to use them smarter. And then, at the end of the day, this is about competitiveness, because we need to develop new skillsets. And I can speak at least for the company I'm president of, that this creates a lot of new and interesting jobs.

So summing it up, there's technology that can solve a lot of these issues, if not all. Still, we need to innovate around it and figure out how to put it together. It would definitely catalyze the discussions and the implementation of these technologies if we could create more transparency and visibility, and if we could help the consumer, including industry, to understand what it means to implement new technology. And then, as I ended by saying, with some leadership and some good efforts, it's a real win-win situation for us in the United States.

Thank you.

WEINSTEIN: Well, thank you for the exciting perspective of new technology, and obviously, as well, for sponsoring this forum and letting us talk through these very important issues as we see fit. It is now a pleasure to introduce Kassia Yanosek, who will conclude our panel here.

KASSIA YANOSEK: Hello, everyone. By way of introduction, I'm a founding principal of Tana Energy Capital. We're an energy investment and advisory firm. I've invested in the energy markets for the past decade. And today, what I'm going to do is provide my perspective on investing in innovation as a solution to some of the water and energy challenges that we have. And I'm going to essentially talk to you a little bit about clean energy markets because many people say clean energy is a solution to a lot of our challenges. And I'm going to talk about where the trends have been from an investment perspective, what the policies have been, and what the implications have been for that, and then some solutions that I see that are important.

So first, I'm going to give you not the bad news, but the challenging news here, which is that despite the fervor you've heard around clean energy, overall investment trends are showing signs of distress and shifts away from markets like Europe and the United States. Stark reality number two is that investors are often rewarded for investing in conventional, less risky projects like large-scale wind farms, instead of the more innovative technologies, and I'll explain why that is. And thirdly, I'm going to touch on the challenges of policy, and the policies to date that have been creating this boom-bust cycle of investment, which, again, has been focused on projects that are quick and easy to build, instead of innovative ones that will eventually lower the cost of energy over the long haul and solve some of our water and energy challenge.

First, I'm going to show you this great graph of global investment and clean energy over the past six years. Over the past six years, this is essentially a compounded annual growth rate of about twenty-five percent, so quite significant. I will point out here that the majority of this investment—about sixty percent—has been in assets. So essentially infrastructure—again, not necessarily new technologies or innovative technologies. About twenty-seven percent of that $243 billion is in the public markets, and only about $8 billion of that $243 billion is in private equity and venture capital, which is going toward more growth investments.

So to juxtapose the prior graph to this one, this shows the past five years or so of stock prices of the WilderHill Clean Energy Index, which is a basket of about a hundred stocks in the clean energy markets. First you see this huge growth rate of investment, yet you see stock prices that have really gone down quite precipitously. And the question is, why is that? That seems strange, where you see huge investment in one graph and yet values plummeting in the other. So essentially, the index's still at about fourteen percent in 2010. So this doesn't actually show very well what's happened in the last year or so. And the WilderHill's underperformed the S&P 500 by about twenty percent. The question is, why is this? Why do you see such huge investments here, yet, you know, valuations that have clearly not been up to snuff?

There are a couple of reasons. First of all, the stimulus dollars that have been pulling a lot of this growth are actually not necessarily fueling values, and the markets are aware of that. Secondly, I'd say that a lot of these stocks are related to companies that have equipment like solar manufacturers, et cetera. And most of the data for the $243 billion that's been invested in the sector have actually not been public market investments. These have been infrastructure investments, so it's comparing apples to oranges. And finally, I'll just end with this because this is going to impact some of my discussion in my later slides, is that the market really is not attributing value to the stimulus funding that's occurred in the past couple of years. And that makes sense, because, you know, the market values are based on the future. Cash flows are expected from a company. And if the stimulus dollars are short-term, then they actually should not result in valuations that look greater than they should.

What is the problem that we have here? I'll talk about stimulus a little bit later, but this slide actually shows the example of a boom-bust cycle of policies and investments that have occurred in the wind sector. This graph shows every couple of years the production tax credit, which is a thirty percent tax credit for wind power and wind production, that is really critical to the industry. And essentially, this policy has been extended or expired every couple of years, and you see a very, very strong correlation between the extension of a credit and what happens with investment. When people see that we're going to have the tax credit around, then they'll invest. When they see that it's going to expire or they're not sure if it's going to expire, you will not see investment. And the reason for this is this graph here. This shows the importance of the subsidies, in terms of the production tax credit and the investment tax credit, to the wind and solar industries. This pie represents the returns to investors—so if the return to an investor for a wind farm is ten percent, forty-seven percent of that return is based upon the electricity sale revenue. The remaining fifty-three percent is actually coming straight from a government subsidy or a depreciation benefit as a result of a subsidy.

With solar, it's actually even greater. And these numbers may be a little off; this is from a couple of years ago, actually. With the solar graph, we're showing the California cash incentive. That's not necessarily applicable, obviously, to every state. But essentially the electricity sale revenue makes up between thirty percent and, I would say, about fifty percent of the total value and return to an investor.

So for both wind and solar, it's very clear that without the production tax credit or the investment tax credit, these technologies are really not economic. And it goes to show that, if we're going to think about the future of the industry, the future sustainability of the industry, it's not going to be based on government subsidies and grants that are not only short-term in nature but also very challenging in today's fiscal environment.

And this graph just shows the global spending on clean energy. Essentially, the bulk of it is happening right now, in 2010 and 2011. So you'll start to see a drop-off. You've already started to see a drop-off, if you've been listening to the news about many markets in Europe, where the feed-in tariffs and some of the subsidies that the Germans and the Italians and Spain have provided to the markets have actually been retracted.

What we're headed for, essentially, is, I think, a very good place to be, which is a redefinition of what a policy goal is, if we're going to have policies to promote the advancement and the investment in clean energy and in innovation—and what should that look like?

What I'm going to jump to now is where I think that policy should go. And as an investor, I care very much about seeing that if there is going to be a policy that I'm going to invest around, that it's actually addressing a real need and is going to stick around.

What this graph shows here is the different risk-return profiles within the energy sector. And you can apply this to water as well, in terms of innovation. On the far left-hand side of the graph, this is the early stage—very early technologies, whether it's early-stage biofuels like algae, very early solar tech development, early-stage battery technology—this is often funded by the venture capital markets.

And on the far right-hand side of the graph is utility-scale, proven technologies —wind, solar, transmission, proven geothermal. The ones that I was talking about are the majority of investment in that $243 billion—that's going to these utility-scale projects. Most of these projects are actually financed by a combination of tax equity, which has been supported by the tax credits as well as debt, and a little bit of equity from the markets. That actually should not require government financing, unless the economics really don't make sense.

The middle piece is where I think I see a real opportunity and a real challenge for the markets, and a place where government can play a role, if you have a goal of accelerating a transition to a new energy economy or a new water economy. And that's where the private sector will not participate without government support because the scale-up risks for a first commercial project are just too great for the amount of return that these investors will get out of the project. So the risk-return profile is a bit challenging when you have, say, a carbon capture and storage project that's going to cost $2 billion, yet the risk profile is actually more like a venture capital project.

So this is the area that I think is most important to address, and I think it's actually very critical. Here is my solution slide. I'll quickly go through this. Going back to this commercialization gap first; one of the policies that I think has tried to address this gap, but has had a lot of challenges, is the loan guarantee program. So you could actually say that Solyndra, which we all know about here in Washington, could fit into the commercialization gap.

I think that we can have a long discussion about where Solyndra should have been funded. I think that, if you're using stimulus dollars as a rationale to be investing in the energy sector, it actually should be to stimulate jobs, stimulate infrastructure development, that sort of thing. Stimulus dollars should not necessarily be used for R&D, because that's not going to get you to your goal. So Solyndra—having had to lay off a number of people—was a risky proposition for the government. That being said, the loan guarantee program was designed to address the commercialization gap.

There is another policy that's been in Congress for a while called CEDA, the Clean Energy Deployment Authority, which would actually give the ability for public-private partnerships to come together and actually fund energy projects without the government's necessarily being involved in "picking winners." That's one policy that could be addressing some of the innovation challenges we have. Also, the Department of Energy today has a really neat program called RPE, which is more aimed at addressing some of the earlier-stage innovation challenges.

But there are no easy solutions. The commercialization gap is a very challenging one. It's one that the Department of Energy has been trying to address for a very long time. We had a whole history of projects that have not gone so well, with government funding aimed at the commercialization gap. So I think that, if we are going to focus on innovation, we really have to hone in on this challenge, as opposed to trying to find policies that fit every solution under the sun.

I'm going to close with some suggestions, which would be, first of all, promoting policies that pull technologies into the market rather than push them into it. This allows the market to actually compete. Ideally, that would be a carbon price; I think we've all agreed on that, and I'll move beyond that since that doesn't seem to be a near-term solution for us. But a federal clean energy standard could get us there. Again, that's politically challenging.

But what I am saying, though, is that we need to stay away from specific subsidies for technologies such as wind and solar which, again, are quick and easy to build, but are not necessarily going to get us toward that innovation goal.

Secondly, if we're going to be putting our funding into the new energy economy, we should be closing the funding gaps, the commercialization gap, the technology gap that occurs when technologies are leaving the universities but don't necessarily have the funding yet from the venture capital industry. There are certain funding gaps that government money can be used for.

And then finally (and we didn't really talk

KENNETH WEINSTEIN, GARY LIBECAP, SHEILA OLMSTEAD, JES MUNK HANSEN, AND KASSIA YANOSEK about this too much today, but it certainly deserves attention), engaging with the emerging markets for a lot of the growth in consumption that's going to occur. Some of these emerging markets—in Asia, for example, and in China—actually have access to cheaper dollars than we necessarily do in the United States. So we should think creatively about partnerships and ways to use those emerging markets as tests for these really high-cost projects, high-risk projects. Thank you very much.

WEINSTEIN: We've had four really extraordinary presentations. It's been first-rate and fascinating. I have learned a huge amount, and I suspect others have as well.

Thank you to my Hudson Institute colleagues. Thank you to our panelists. Thank you to Grundfos for sponsoring this conference, and also thank you to our online audience for watching as well. Thank you, and good day.

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