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# NEW DIRECTIONS FOR U.S. ENERGY POLICY

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Former U.S. Treasury Secretary

**Overview of the Energy Landscape:**

DAVID J. O'REILLY
Former Chairman and Chief Executive Officer
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ROUNDTABLE: THE FUTURE OF U.S. NATURAL GAS:

**Moderator:**

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ROUNDTABLE: INVESTING IN CLEAN ENERGY INNOVATION:

**Moderator:**

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**Panelists:**

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MODERATED DISCUSSION: CHALLENGES AND OPPORTUNITIES FOR AMERICA'S ENERGY FUTURE:

**Moderator:**

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P R O C E E D I N G S

**Welcome and Introductions:**

SHERYL SANDBERG
Chief Operating Officer
Facebook

MS. SANDBERG: So, good morning, everyone. It is my distinct pleasure to welcome the Hamilton Project to Silicon Valley and to Stanford University. I think as this group knows, the Hamilton Project's goal is to foster economic growth and not just any economic growth but economic growth as inclusive on economy that works for more people, because the economic growth is generated by more people.

So, I'm biased, but I think Silicon Valley is the perfect location for this meeting. We're very aware of our good fortune that even in today's world we're one of the few bright spots where companies are more likely to be worried about not being able to find enough employees than people are likely to be worried about unemployment. But I think the hope all of us have who work in Silicon Valley is that we don't just

create economic growth for our own little community but we create economic growth throughout our economy, throughout the United States, and even throughout the would.

As the Hamilton Project studied and wrote last fall, the technology developed here creates productivity and growth not just for the tech sector or the energy sector but for durable goods, for farming, for agriculture, cleaner water, pharmaceuticals, so many different sectors around the world.

Today's focus for the Hamilton Project is on energy policies, and the goal is to explore innovation but couple that with our long-term energy and environmental goals. We think this is a critically important conversation not just globally, not just at the national level and the local level but also at the company level.

I work at Facebook, and we think of ourselves as a platform to make the world more open and connected, and that platform, in our view, has to

be used to achieve some of these goals. We've partnered with the NRGC and a startup called Opower to create an app that lets consumers monitor and share how much energy they are using, trying to put the social power together to help people understand their energy use and, also, you know, create a community of friends and family who care about that as well.

Last year we did an open computer project. We were able to achieve 38 percent efficiency in our own data centers. And rather than keeping that as a secret for our own company, we open-sourced it, and we've been really pleased with some of the other companies that have joined in. Our view is that this has to be a problem we all solve together.

So, this may be a very long way of saying that we think this meeting belongs in California. Now, apparently when it was first suggested that this meeting was in California, Secretary Bob Rubin said, "We are not California people." My goal is that by the end of today, when you've spent time here, you will know that this is a great place to have this

conversation about these challenges.

Now, it's my great pleasure to introduce the opening speaker this morning, one of the founders of the Hamilton Project, the co-chairman of the Council on Formulations and former Treasury secretary, Robert Rubin.

I had the opportunity to work with Bob longer ago than either one of us wants to admit, when he was at Treasury. I'll never forget my very first meeting in his office. He was kind of scary, not because he's really scary but because he was, you know, Secretary Rubin. And I got invited to a meeting and we were in his conference room and I was sitting in the back corner, and I'd been at Treasury about a week. And everyone's talking, and then he says, Sheryl, what do you think? Jaw open, no response, I was just shocked to be asked. And when I looked shocked, he kindly said, well, you know, I wanted to ask you because you're new here, so you may see things the rest of haven't seen yet.

And I thought that was a really powerful

lesson. And he continued to display that when he was running Treasury and I think in everything he did, which is that you learn from open dialogue, you learn from the facts, and you learn from including everyone in the conversation, which I know is what the Hamilton Project is doing by being here today. So, I think he's the best opening speaker we could have. And my personal goal, of course, is to make him a California person.

Please welcome Bob Rubin.

**Introduction and Roadmap of Event:**

ROBERT E. RUBIN
Co-Chair, Council on Foreign Relations
Former U.S. Treasury Secretary

MR. RUBIN: Thank you, Sheryl. And I bring all of you greetings from Madison Avenue. In any event, those really were very gracious and very kind remarks.

I remember the first time I ever met Sheryl. Sheryl had come to Treasury to work with Larry Summers. Sheryl is a member of our Advisory Council now at Hamilton, and so is Larry. And Larry said Sheryl is the brightest student he had ever had at Harvard. And Larry wasn't all that inclined to refer to other people in that gracious of -- I mean, he's a very gracious guy, but he also has high standards. And Sheryl has done reasonably well since then, and Sheryl and Larry and I have really remained very good friends.

So, again, I thank you, Sheryl.

Let me welcome all of you on behalf of our

co-sponsors -- Stanford University and The Hamilton Project -- to our joint program, New Directions for U.S. Energy Policy. As we all know, this is a time of dynamic developments with respect to energy both in the United States and around the world. And these developments, to use a colloquialism, are truly game-changing with respect to our economies, national security, the environment, geopolitics, and much else.

The combination of one of the world's truly great universities and its many departments focused on energy with the Washington-based policy focus of the Hamilton Project brings together into one discussion multiple perspectives, and I believe that should enable all of us to enlarge the way that we think about these critical issues.

Let me briefly provide some information on each of our organizations before proceeding with the program.

To start with, Stanford is heavily engaged in matters of energy while at the same time working to protect the environment. Two hundred faculty members

are working on energy-related problems, and that work spans 7 schools; business, engineering, or sciences law; humanities and sciences; education to medicine; and it spans 22 academic departments and more than 2 dozen independent labs. The research covers a broad portfolio from technology in conversion, storage, management, and transmission to the mitigation in the use of energy through sensible policies. And all of this is accompanied by educating the next generation of energy leaders.

Turning to The Hamilton Project, we have had a really wonderful experience in working with Stanford, and our hope is that in the future we will do so again. Since this is the Hamilton Project's first policy discussion in California, let me tell you a little bit about who we are and what we are.

The Hamilton Project began roughly six years ago within The Brookings Institution with perhaps a unique combination of policy experts, academics, former public officials, and business people who were engaged in the political process. All of them put

together formed our Advisory Council, which is sort of an analog to a partnership. The guidance and participation of the Advisory Council with its wide range of experience, viewpoints, and perspectives give The Hamilton Project, I believe, a distinctive look on policy issues. We don't endorse specific ideas; rather, we conduct serious policy discussions on critical economic issues using academic and policy experts and practitioners from around the country. When those discussions include papers as, for example, they do today, they are subject to serious peer review. In a very real sense, what we do is bring together seriousness of the purpose around policy issues with the practical and political realities of Washington.

The Hamilton Project has convened deliberations with respect to trying to help contribute to addressing the enormous hardships that far too many Americans are experiencing today, but our primary focus has been long-term economic policy. And as Sheryl said, we believe that the objectives of

economic policy should be growth, broad-based expansion of opportunities and living standards, and economic security; and we believe that these objectives can be mutually reinforcing. We support market-based economics, but we also believe that government has a vital role to fulfill the purposes that markets, by their nature, will not fulfill.

And that takes us to today's program. We'll start with a broad focus on the outlook for energy supply and demand in the United States and globally. Our presenter is David J. O'Reilly, former chairman and chief executive officer of Chevron.

And I'll say, with respect to David and all of the participants and moderators, I'll mention their titles, but I won't go into their resumes, because they are in your material.

After David's presentation, he'll entertain comments and questions from all of us.

Our first roundtable is entitled "The Future of U.S. Natural Gas." The panel will begin with three papers to discuss key issues with respect to shale gas

and policy ideas to address the issues that are raised. The authors are Lucas Davis, assistant professor of economic analysis and policy, University of California, Berkeley; Chris Knittel, professor of energy economics, Massachusetts Institute of Technology; and Michael Levi, senior fellow, Council on Foreign Relations.

After the presentations, the authors will engage in discussion with two distinguished discussants: Katy McGinty, managing director for strategic growth, Weston Solutions, Inc., and former director of the White House Council on Environmental Quality; and Barry Smitherman, chairman of the Railroad Commission of Texas. The moderator will be Michael Greenstone, director of the Hamilton Project, and 3M professor of environmental economics at the Massachusetts Institute of Technology.

The second panel is entitled “Investing in Clean Energy Innovation,” and will focus on technological innovations in the energy field. The discussants are Sally Benson, director, Global Climate

and Energy Project, Stanford University; Kenneth Hersh, co-founder and CEO, NGP Energy Capital Management; Vinod Khosla, Khosla Ventures, former chairman and CEO, Sun Microsystems; and Jim Rogers, president and CEO of Duke Energy. The moderator will be Hemant Taneja, managing director, General Catalyst Partners, co-founder, Advanced Energy Economy.

And the final panel, entitled “Challenges and Opportunities for America’s Energy Future,” will be a broad-ranging discussion of the energy issues that our country and the rest of the world face. The discussants will be the Honorable Jennifer Granholm, distinguished practitioner of law and public policy, University of California, Berkeley, and former governor the State of Michigan; Admiral Gary Roughead, Annenberg distinguished visiting fellow, Hoover Institution and the former chief of Naval Operations; George P. Schultz, who has been sort of everything, amongst which are U.S. Secretary of Labor, U.S. Secretary of the Treasury, U.S. Secretary of State, and the head of OMB; and Tom Steyer, senior managing

member, Farallon Capital Management, and co-chair, Californians for Clean Energy and Jobs. The moderator will be Robert Altman, chairman and founder of Evercore Partners and former deputy secretary of the Treasury.

Before moving into the discussion, let me make two points. Firstly, as we all know, the development of newly available or newly discovered energy, gas, and oil reserves, all pose environmental challenges. The challenge then is to develop regulation that provides optimal cost-benefit balance between the economic, environmental, and national security opportunities on the one hand and strong protection against the environmental and health risks on the other. And that includes not only the direct costs and benefits but also the indirect costs and benefits, that is to say the positive and negative externalities.

The problem is that too often in our country and around the world, the political and regulatory processes do not engage in this cost-benefit analysis

in an effective fashion. Too often the regulatory systems tilt either toward underregulation or overregulation due to the influence of organized interests of all sorts and of politics. And I don't think that there's any question but that everything we will be discussing today depends on getting this balance right. The stakes are enormous, and there is a great deal to do to provide us with the regulatory processes, the making of rules, and the application of rules that will enable us to find that optimal place on the cost-benefit spectrum.

Another similar issue is policy making with respect to funding new technologies, basic research, technological development, and the like. What is needed is a rigorous, nonpolitical, and objective evaluation of funding with respect to these projects. And, unfortunately, once again our system is often found wanting; and mistakes, once again, in getting this right are enormous. And in both cases it comes back to the functioning of our political system.

With that framing, let me turn to our

program and welcome to the podium Dave O’Reilly.

Thank you all.

**Overview of the Energy Landscape:**

DAVID J. O'REILLY
Former Chairman and Chief Executive Officer
Chevron Corporation

MR. O'REILLY: Thank you, Bob. Appreciate it. Thanks.

Good morning, everybody. I'm delighted to be here with you this morning, and I look forward to a very productive day. And I'm going to try to set the scene with some facts and figures that I hope will help with the discussion.

On my way over here today -- I'm about an hour and a half away -- I was listening to the hearing in Washington where Jamie Dimon was being grilled by a panel of Senate Banking Committee people, and they were trying to define the difference between trading -- proprietary trading, I guess -- and hedging. And after 30 minutes I got so upset with the circular arguments that were going on, I just turned it over to XM Radio 70, which is "B.B. King's Bluesville," and I arrived in a much happier state of mind. (Laughter)

And I'm even happier to be here as I know we're dealing with something in the future and maybe we can do something productive as a result of our discussion.

So, my plan is to talk about, really, three issues. One is the global energy supply and demand system, looking at it somewhat historically, and then focus on the U.S. energy supply and demand system and talk a little bit about some of the constructive things that have happened in recent years, particularly in the area of natural gas supply, and then I'll stop and pause for questions. So, let me start.

I'd like to talk about scale, because the energy system is very, very large. In fact, it's very hard to describe it in terms of BTUs, so I convert everything to liquid. What does it look like in liquid? If you include all sources of energy -- nuclear, oil, gas, hydrothermal, geothermal, you name it -- it's equivalent to 125,000 gallons per second, which will fill up this room in about 10 seconds. So, every 10 seconds this room would fill up with the

energy that the world is consuming on a global, worldwide basis. So, that's an enormous amount of energy when you think about it, and I think that's something that we all have to keep in mind, because to change the system does take time when you consider the capital stock investment, and overnight change doesn't happen very easily, certainly not at scale.

Here is a picture now of all of the different sources of energy still expressed in terms of liquids, 250 million barrels equivalent per day. Now, you can see that in 2009, which is the last International Energy Agency data, the total oil, gas, and coal part of this is about 80 percent of the total pie, nuclear at about 6 percent, and 13 percent is renewables. I'm going to talk a little bit about what makes up that renewables piece in a moment. But you can see that predominantly, as it has been for quite for some time, energy is supplied from oil, coal, and natural gas.

Now, what's happened in recent history -- and by recent history I'm talking about the last

30 years, from 1980 to 2009 -- first of all, if you look at the left-hand bars, total energy supply and demand has grown by two-thirds. Two-thirds. And all sources of energy have expanded during that time. In absolute terms, coal, natural gas, and oil have the largest absolute increases, and those are the bars on the right-hand side of this chart, and in percentage -- and this is a little bit surprising and not necessarily intuitive -- nuclear has had the biggest percent of increase; natural gas second; coal, third; and fourth has been renewables. And then, finally, oil has been the lowest as a percent of the base that existed in 1998 compared to what's recently happened in 2009.

Now I want to focus on the yellow bar. That's that piece called renewables. And this chart breaks down what that renewables piece is. You recall that that renewables piece is about 7 or 8 percent of the total pie back in 2009. You can see that -- I'm sorry, 13 percent. Of the 13 percent, 70 percent or so is waste and biomass. And to a large extent that

is firewood, dung, and the like, that's burned all over the world. It's been estimated to be about that number from the International Energy Agency. About 18 percent is hydroelectricity; 5 percent is biofuels, predominantly ethanol; 4 percent geothermal; and 2 percent is comprised of wind and solar and other miscellaneous sources of energy. So, predominantly when we look at the global picture for renewables, that 13 percent or so is made up of firewood and dung on a global basis.

What's happened over that 29-year period to energy demand? In 1980, almost 60 percent of the energy consumed in the world was consumed in OECD nations. Now, remember that demand has grown by two-thirds in that 29-year period, and now 44 percent is OECD; 37 not only OECD; and China, which was 8 percent of the smaller pie in 1980, is now 19 percent of a much, much bigger pie in 2009 and has continued to grow subsequent to this data.

Now, don't be misled. Even though the piece of the pie for OECD has become smaller, OECD demand

during that 29-year period grew by 30 percent, but not-only-OECD demand grew by 120 percent.

Let's now turn to the U.S. and see what's happened here. Now, here we do have data for 2010 from the U.S. Energy Information Administration, and I'd like to compare the data to 1990 just for convenience. Now, you can see here that interesting enough, over this period of time, the picture hasn't changed very much. Oil, natural gas, and coal make up about 84 percent of energy demand; not too different from where it was in 1980. And nuclear and other, which is -- in this case they call it "other" -- that "other" by EIA standards is actually mostly renewable. They call it "other," but it's mostly renewable. It has increased kind of modestly during the period of time.

Now, I want to focus on that 8 percent of "other" and talk about what is it in the case of the U.S. Here you can see that it's predominantly hydroelectricity, 31 percent; biofuels, which is predominantly ethanol, 30 percent biomass. And here

the biomass is mostly byproduct of the paper and pulp industry, as well as the byproduct of ethanol manufacture itself. So, this is not the same as the rest of the world. This is a more focused, commercially based biofuel and biomass consumption. And then wind is at 12 percent; solar voltaic, interestingly enough, is only 1 percent. And remember, that's 1 percent of 8 percent. So, the total energy supply in the U.S. in 2010, .08 percent was solar voltaic.

I'm not making any judgments about good or bad here. I'm just giving you facts.

How is energy consumed in the U.S.? 1990 to 2010, again, the biggest chunk goes into power; the next into transportation, as you can see; commercial and residential; and industry, interestingly enough, over the 20-year period has actually not grown at all. It's been pretty flat. I think that's just a reflection of the shift in the knowledge economy; the fact that much of industrial production is occurring in other parts of the world; and also I think, in

part, a result of some of the regulatory requirement that inhibits or has inhibited manufacturing and more energy-consuming industries from developing in the U.S.

Just to show you how important all the different sources of energy are, though, in the U.S., let me just point out -- you have to look at this chart a little bit carefully -- you can see that power as of -- this is interesting -- as of 2010 was almost 50 percent coal and about 25 percent natural gas. Now, interestingly enough, with the advent of shale gas, that has changed already to much more equal numbers of coal and natural gas so that natural gas is now up to the 30 to 35 percent of this pie in as little as 2 years, and coal has declined to about 30 to 35 percent.

You can see that oil is the primary supply to transportation, and then the industrial demand is a mixture of natural gas and oil and renewables, et cetera, and then commercial and residential, of course, is primarily natural gas with a little bit of

oil primarily in the East. The point here is that all forms of energy have a role, and this is how they're currently being used.

I did want to talk to you a little bit on economics, and it's very hard to find data, but the EIA has done some analysis of the cost of new power generation data to 2017 using, I think, about $5 gas as opposed to the $2.50 gas that we see today. But here you can see the relative cost of different sources of energy, and you can see that in relative terms that hydroelectricity and wind are actually quite competitive based on this analysis. But because the green sources of electricity are intermittent where the blue sources of electricity are dispatchable and predictable, generally, this analysis is a little flawed, because it doesn't take into account the backup power you need in today's environment to supply energy when the intermittent sources are not performing. But it does give you an idea of the relative economics, and it does show that hydroelectricity and onshore wind are now, you know,

reasonably competitive. And photovoltaic I think has improved in its economics since this time, because the cost of panels has come down since this analysis was done in the last, I think, about six months ago.

I want to make a pitch also here for the importance of energy efficiency. This shows you the change in energy intensity. That's the use of energy per unit of GDP from 1980 to 2009. Now, you can see that comparing China, U.S., EU, and Japan, all have improved. Japan, of course, leads the parade in this regard. It had an early start, because it was so badly affected by the oil disruptions of the early 1970s that it undertook energy diversification and energy efficiency much more aggressively and earlier than the rest of us did. But all have improved, and even China has improved substantially. And on a recent visit to China, it is quite clear that energy efficiency is something that the government there is really promoting and working hard at, because it recognizes that this is something that is going to be good and, in fact, necessary for their economic

wellbeing and social wellbeing in the future.

I've now flooded you with a lot of facts. I want to just touch on a couple of points about energy supply in the U.S. from a recent natural Petroleum Council Study that was conducted, which was, in a sense, a study of studies as well as independent work done by the National Petroleum Council, which I have chaired for the last two years and I'm now in my last month or so of my commitment there.

Secretary Chu asked the National Petroleum Council, which is an advisory council to the administration which was formed in 1948 by President Truman, to study the energy supply situation in North America with particular attention to peak oil and what the implications for greenhouse gas emissions might be. There were a number of questions, but that's, in a sense, kind of a broad-based summary of what he requested back in 2009. And the study -- which was undertaken by hundreds of people, not just from the oil and gas industry but also NGOs, consumers, as well as industry who are consumers --

presented its findings almost a year ago to the secretary. And these are the main findings, and I'll let you just read through them. Very, very positive outlook for natural gas relative to what was thought as recently as in the middle part of the last decade, so in the last five to seven years, in fact, in the range of a hundred years' supply at reasonable prices, although it's very hard to predict with a lot of accuracy a hundred years out.

It also painted a much brighter picture of oil resources for the future. And then it pointed out that we need the resources even as efficiency reduces energy demand, because the alternatives, although they are growing -- and when I talk about alternatives, I'm talking about the importance of renewables -- were judged to be coming on, on a commercial basis, at a slower pace, and the reality of they're being able to achieve a substantial portion of energy supply in the next 25 years or so was judged to be very low.

So, the importance of having a diverse supply and having security of supply in the U.S. was

an important finding, and of course realizing the benefits of production would be entirely dependent on environmentally responsible development during the future as we develop these resources.

I think it's very interesting that the shale gas revolution, as it's been called, has now drawn attention to the prospects of an energy supply system that could make the United States much more secure than we thought in the past, particularly if we can extend what we have discovered in natural gas to the supply of oil.

So, the key observations I think from all of this as we look forward are as follows. The composition of energy sources in the U.S. makes us secure in energy for industrial and power generation because of our natural gas resources and coal. So, I think compared to what we assumed even as recently as five years ago, I think that first finding is an important one.

The second one I think is that the U.S. is likely to remain reliant on oil, and I should say oil

imports, for the next 25 years without a significant technological breakthrough in transportation. I have a more measured view than some of our potential to generate sufficient oil from shale prospects to be as successful as we have been with natural gas. So, my view is that I think we still have to worry about the transportation system, because you'll recall one of the earlier charts shows that transportation and oil kind of go together, so what are the things we need to do to make that more secure, and I don't think we can count on totally resolving our need for imported oil. We can reduce it, but from the supply perspective I don't think that's sufficient. We'll have to work on alternatives there.

And of course there is enormous potential to improve energy efficiency across all sectors of the economy if you were to take the U.S. picture and improve energy efficiency to the scale of what Europe has been able to achieve. I think the equivalent of about 10 million barrels a day -- not necessarily all oil, but the equivalent energy saving of about

10 million barrels a day, which is about almost 20 percent of our energy demand -- could be achieved.

So, what I'm going to do -- I'm getting flashes that I'm running out of time here a little bit -- I'm going to stop here for a moment and see if there are any questions that I can elicit from the audience.

I would like to make -- well, I've already had one question, and that was about shale gas and the prospects for shale gas development outside the U.S. I think the prospects are there, but it's going to take a lot longer and be a little slower than one might think.

The U.S. has the benefit of hundreds of independent companies working -- with an economic incentive of high natural gas prices -- with an indigenous oil services and supply industry that could supply it with the rigs and the wherewithal it needs to develop it and a pipeline infrastructure for natural gas that's quite extensive -- I mean, thousands and thousands of miles of pipeline, many

thousands of miles of pipeline. So, commercially connecting the product to the market is relatively easy. And landowners, very importantly, share in the benefit because they have mineral rights.

Europe does not give the landowner the mineral rights. The government retains it. So, there's a natural disincentive, if you will, for landowners to cooperate with development. Eastern Europe, which is pursuing this rapidly, or trying to pursue it in many places rapidly, is finding that it doesn't have a strong, indigenous oil supply, oil services business for the rigs and the pipelines, et cetera, and then you have different government policies. It's anything but a united Europe, as we know from just looking at the financial systems today. Well, that stretches through social, compact; it stretches through views of energy where France likes nuclear, Germans want to shut it down. So, this is not a European Union; it is, you know, a European mess. And I just don't see how Europe can be successful under all these varieties of opinions and

different regulations and lack of incentives to perform as we've been able to be in the U.S.

The other question I was asked about shale gas is China. A number of us were in China a few months ago. The Chinese leadership is very interested in shale gas. There is definitely a prospect for development there. It's at its early stages. I think it also will take longer, not because of lack of intention but because there's a lot of exploratory work to be done; there's a lot of infrastructure to be built. And I think they eventually will get there, but it's just going to take longer. So, whoever asked the shale question, that's my own view on shale.

I've been asked to see if there are any questions. I have one back here.

SPEAKER: Thanks for your presentation.

I have a question about the long-term stability of natural gas prices, sort of in general as this rising demand or use of them, you know, increases especially with power gen. What about -- and also the environmental regulations as they start to be --

people start to pay attention to that a bit more. So, where do you think things are going to go in terms of natural gas prices?

MR. O'REILLY: Well, it is unlikely that natural gas prices will stay as low as they are today forever for two reasons, and I don't know which one of them -- which is the chicken and which is the egg. The incremental cost of producing gas, if you include new capital, is probably higher than you can sustain at $2.50 for the long term. So, on the cost side, I think prices will have to come up. The NPC study referred to some work that was done, I think it might have been at MIT, that projected, though, that as prices in the $5 range -- and there might be a MIT person who can help with this -- that prices in the $5 range, which is still very, very competitive, there's a lot of prospect for supply.

The other side of it, of course, is the arbitrage between gas and oil, which is abnormally high, and that drives one to try to find places in the market to substitute gas for oil. And we're seeing

the early signs of that with the trucking industry installing gas engines, with truck stops installing natural gas fueling facilities. So, I think you're going to see the market -- there's a tremendous market driver to consume gas at lower prices, but there's also a cost issue that I think the suppliers are going to have to face that will tend to bring prices up. But I still think it's very positive on a global basis for U.S. competitiveness, and we're seeing it throughout the economy.

The question about environmental restrictions, I think we need a good regulatory system, obviously, for natural gas. It does exist in many places, but because there's a lot of overlap between state regulations, you don't get consistency, and sometimes when the Feds get in, they make it worse. So, I think it's well to remember that a lot of this happened in a positive way without scads of regulation. It was hundreds and hundreds of small companies -- many of them quite small -- that made these breakthroughs, invested, and generated, in a

sense, created a new frontier for energy supply for the country. I'm not saying regulation is bad; I'm just saying that it needs to be done in a sensible way.

Yes. One here and then one here.

SPEAKER: I have a two-part question around your second bullet. First, you referred to the need for a significant technological breakthrough to break the dependence on foreign oil with respect to transportation. I would have thought what's needed is a commitment to build the infrastructure to move from oil to natural gas on transportation as opposed to a technological breakthrough. So, I'd just like your thoughts on what you're referring to on the breakthrough versus just getting the infrastructure for natural gas to power transportation.

And then the second is if that breakthrough or commitment occurs, do you think the supply of natural gas domestically is deep enough to commit the full transportation sector to natural gas in a secure way?

MR. O'REILLY: Okay, good question.

I'm a bit nervous about committing our whole transportation system to natural gas yet. I think that's a big risk to take, and there's always benefit in diversification of supply. So, what I meant here, first of all, in the case of natural gas, there is a technological breakthrough required, because compressed natural gas -- there are more efficient ways through maybe liquefaction that could make natural gas even easier to accommodate in the transportation system. And so there are things that can be done in improving the engine and in the form of the gas supplied that does require technological breakthrough.

The other technological breakthroughs, of course, are batteries. Can we ever get a battery that I don't have to -- you know, I charge this thing twice a day. I'm a pretty heavy user. You know, we've got a ways to go on battery density and longevity that needs to be worked. There are biofuel opportunities, but they're going to have to come from a broader array

of supply than just ethanol from corn. I mean, there are things that I think we need to work on here, because I do believe we will still be importing oil 20, 25 years from now, and I do believe that that's the one area of vulnerability that we have in our supply system. So, looking at it from an energy security standpoint, this is why I mentioned we do need technological breakthrough.

Yes. Thank you.

SPEAKER: Thank you. The comments you made about natural gas prices seem to be related to the U.S. or North American market. Prices in the international market, such as Asia, are substantially higher than that. Do you have any comments on the outlook for natural gas prices long term globally in the global market?

MR. O'REILLY: I'm hopefully wrong about predicting prices and have been for decades, I'm afraid. But, you know, I believe the market works, and I just don't think that the arbitrage -- the arbitrage between oil and gas prices is so high that

with time -- I mean, this can't switch overnight, but with time and investment that has to narrow, you know, if you just believe on fundamental economics. And right now when you look at Asia, you're comparing an oil supply with a gas supply. In the U.S., gas is competing with coal, and coal is relatively low cost. So, incremental gas is now competing with coal, which is why it is so low. But as the markets globalize, and as all these markets connect, and as more shale is found in other parts of the world I believe that this could be a healthy thing for the economy and then that will narrow, but what the number will be, it's very hard to predict.

I have -- we've got to go -- a one-minute sign here from the very rigorous timekeeper, which admire and support. (Laughter) So I'll take one more question.

SPEAKER: I have a question about what you mean by security. In your view, is the best way for us to think about energy security to think about domestic supplies and security of domestic supplies or

adequacy of domestic supplies? Or is it, to think more broadly about the resilience of our economic system, to price shock the energy system?

MR. O'REILLY: Good question. I think it's how much domestic supply you have. It's also the diversity of your supply, because these things are so unpredictable. I mean, the most recent example is we're building import terminals for natural gas four or five years ago; now we're converting them to export terminals, or at least some of them to export terminals. So, it's a matter of all of the above. And I also mean trade regulations. You could even say geopolitical relations. The more we collaborate internationally so that there is a free flow of trade, the less vulnerable we will be to disruption. So, there are a lot -- I mean it in the broadest sense, this whole issue of energy security, not just solely our supply.

Thank you a lot for your questions. I apologize, I can't take any more, but I need to get to the panelists.

**ROUNDTABLE: THE FUTURE OF U.S. NATURAL GAS:**

**Moderator:**

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3M Professor of Environmental Economics
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Council on Foreign Relations

**Discussants:**

BARRY SMITHERMAN
Chairman
Railroad Commission of Texas

KATHLEEN McGINTY
Senior Vice President and Managing Director for Strategic Growth, Weston Solutions, Inc.
Former Director, White House Council on Environmental Quality

MR. GREENSTONE: Okay. My name is Michael Greenstone and I'm the director of the Hamilton Project. We're

here today, I think, to talk about the biggest transformation in the energy sector in the last five decades. And I'm no engineering expert, but as I understand, what a lonely and industrious man in Texas figured out was that if you dig a really big hole and shoot a lot of water down it and some other stuff and aim that at about 5- to 20,000 feet below the earth, lo and behold, what will flow out is natural gas and petroleum. And that has led to a series of kind of dramatic changes.

As an example, in the last few years shale gas' share of natural gas production's gone from 2 percent to 37 percent in the United States. We now have $2.50 natural gas. As was mentioned a minute ago, in other parts of the world, I think in Asia, it's $15; in Europe it's $11. And so suddenly out of nowhere in maybe three or four years' time, the world seems to be awash in hydrocarbons. And that presents tremendous opportunity.

I think it also presents two concerns. They probably are the legitimate local concerns about how

to manage local environmental risks. And then a question which I don't think we're going to answer today and maybe we can make a little progress on is, is this influx of hydrocarbons, is this the blue bridge to the green future or is the death of renewables and nuclear and other low carbon sources of energy?

And so I think the challenge for all of us today in this, the whole day, is to try and come up with a way to discuss the opportunities and identify policies that can help manage the opportunities while minimizing the risk. And to do that, on this panel we've commissioned -- as a first piece of that, we commissioned three papers that were meant to be kind of seen holistically, and we have three excellent authors to talk about them.

I think the first is Lucas Davis, who's an associate professor at UC Berkeley's Haas School of Business. We have Chris Knittel, who's my colleague at MIT. He's a William Barton Rogers professor of energy economics. And we have Michael Levi, who's a

David Rubenstein fellow at the Council on Foreign Relations.

And to help us digest their policy proposals which they'll talk about in a minute, we're very fortunate to have Kathleen McGinty, who's to my right, who is the senior VP at Weston Solutions, has a kind of incredible resume of other activities, including having been the director of the White House Council on Environmental Quality during the Clinton Administration.

And to my left we have Barry Smitherman, who is the railroad commissioner of Texas. And that might sound strange to why he's here and we'll talk a little bit why the railroads have something to do with --

MR. SMITHERMAN: Nothing to do with railroads.

MR. GREENSTONE: Yes.

MR. SMITHERMAN: Yeah.

MR. GREENSTONE: And --

MS. McGINTY: They run on gas, too.

MR. GREENSTONE: And he was previously the

chair of the Public Utility Commission of Texas, so that's another source of expertise.

We're on a very tight schedule, so I thought we'd just turn it over to Lucas. And maybe, Lucas, you can tell us about your excellent policy proposal.

MR. DAVIS: Okay, terrific. So again, I'm Lucas Davis. I'm an associate professor at the Haas School of Business at UC Berkeley. And I'm delighted to keep the discussion going this morning, talking about modernizing bonding requirements for natural gas producers.

So as we've already talked about this morning, hydraulic fracturing and other recent technological advances have dramatically increased the availability of natural gas. Over the next three decades, shale gas production is forecast to more than double. One of the key challenges for policymakers is how to allow the continued development of this valuable economic resource while also making sure that drilling is done in an environmentally safe way.

As Michael already eloquently explained,

hydraulic fracturing requires injecting immense quantities of water, sand, and chemicals at high pressure in the horizontally drilled wells. Environmental groups are concerned in particular about the potential for the contamination of groundwater and about the increased scope for large volume surface spills of fracking fluids. Although the scope for environmental damages is still poorly understood, it's not too early to begin thinking about the incentives faced by natural gas producers. And here producers face a misalignment of incentives. Revenues from drilling are realized almost immediately. Environmental damages, though, are not realized often for many months or years after drilling has happened.

And what can happen is that by the time environmental damages become evident, the companies that did the drilling may no longer exist or may not have the financial resources necessary to pay for damages or to compensate those that have been affected. This is particularly problematic with fracking because the market consists of a large number

of small- and medium-sized companies. So as of March of this year, there were over 100 companies actively drilling deep, horizontal natural gas development wells in the United States.

This is actually a remarkably low level of market concentration. It's about a quarter of the market concentration you find in oil drilling on the right -- deepwater oil drilling in the Gulf of Mexico. This matters because bankruptcy laws limit these producers' liability. For many of these companies, potential environmental damages exceed the total value of the company, so the tort system provides an insufficient deterrent.

This is a problem both because it means that funds may not be available to pay for cleanups, but also because it means that these companies may not face the full incentive to act prudently when making decisions about drilling.

So what can be done? My proposal highlights bonding requirements as a key policy tool. This is not a new idea. The 1920 Mineral Leasing Act

establishes that oil and gas drillers in the United States must post a bond prior to drilling on public lands. If environmental damages occur, this bond can be used to pay for damages. If no damages occur, the company gets that money back with interest.

This approach makes a lot of sense, but the minimum bond amounts are inadequate. The current minimum bond amount, $10,000, was established in 1960 and has never been updated for inflation. This is not enough to pay even for routine site reclamation expenses like plugging the well, and is a negligible amount compared to the dollar value of damages when accidents occur.

So this proposal would first increase minimum bond amounts for all drilling under jurisdiction of the BLM. Adjusting for inflation, the bond amount goes from 10,000 to $60,000. So it would make sense moreover to permanently index that dollar amount to inflation to prevent this erosion of the real value of the bond over time.

In addition, the evidence supports further

increasing minimum bond amounts above that that's implied by the inflation adjustment for wells constructed using hydraulic fracturing. These are larger and riskier operations than the shallow vertical wells for which this legislation was designed. And the use of millions of gallons of chemically treated fracking fluids in fracking introduces new risks that simply are not present in conventional drilling.

We'd have to do a couple of other things. States would be encouraged to adopt similar requirements for drilling on non-federal land. This is crucial because two-thirds of drilling occurs on non-federal land. This is already an area of active legislation. Pennsylvania and West Virginia, for example, have recently moved to increase their minimum bond amounts.

Finally, the proposal would eliminate the existing blanket bond provisions that act as liability cap and decrease the average bond amount per well to an unreasonably low level. Taken together, these

changes would dramatically strengthen the existing system of bond requirements. It would create a source of funds that would be available when environmental damages occur, but I think more importantly, incentivize gas producers to work hard to make good choices to avoid environmental damages altogether. Thank you. (Applause)

MR. GREENSTONE: Next, we have Chris Knittel.

MR. KNITTEL: Great. Well, thanks, everyone, for being here. So the motivating picture or graph for my study or my discussion paper is this. So this is the ratio of oil prices to natural gas prices on a per energy basis. And despite the recent drop in oil prices, the oil is trading at about a six-to-one ratio in terms of energy content with natural gas. Because of the lack of oil use in other parts of the economy other than transportation -- transportation ends up being the most -- the obvious place to arbitrage this price difference.

And there's three ways to do that in

transportation. One is that we can use methanol as a drop in fuel with flex-fuel vehicles. Methanol is currently trading, wholesale methanol price is currently trading at below both ethanol and gasoline. The second is that we can run light-duty vehicles and medium-duty vehicles on compressed natural gas. And the benefits from that -- the private benefits from that are substantial. So at current gasoline, diesel, and CNG prices, a 15-mile-a-gallon pickup over the course of its lifetime, the consumer would save over $4,000 from buying a CNG pickup relative to the gasoline or diesel version, and that's after accounting for the $11,000 increase in upfront costs.

The third and probably the most promising is for the heavy-duty industry to rely more on liquefied natural gas. The private benefits here are quite substantial once you consider the fact that many of these Class 8 vehicles are driven 100,000 miles a year and get on average about 6 miles a gallon. So the private savings over the course of a Class 8 truck can exceed $100,000. But the existence of private

benefits are not enough for policy to intervene into the market. If private benefits were all that we had, there would really be no reason for policy to intervene.

The reason for policy to intervene in this market, is that -- there are two reasons. One is that there are a number of unpriced what economists call externalities or social costs that are higher for gasoline and diesel relative to natural gas. And these include greenhouse gas emissions, local pollution benefits, military social costs, and macroeconomic social costs. And these can be substantial and can actually, in some cases, double the social benefit from a shift from petroleum-based fuels to natural gas-based fuels.

So that same 15-mile-a-gallon pickup, the savings in the unpriced social benefits from a consumer shifting from diesel or gasoline to CNG are larger than the private benefits. So without policy to intervene, there wouldn't be a sufficient incentive for a consumer to make that shift. And the same is

true for LNG in Class 8 rigs where the social benefits can be as large as $60,000 over the course of a Class 8 vehicle's lifetime. So left alone, we wouldn't get a sufficient shift from petroleum-based fuels to natural gas-based fuels in the transportation sector.

And the second benefit that petroleum-based fuels has currently over CNG, LNG, and methanol is that they're a large infrastructure disadvantage for these natural gas-based fuels. When you compare the number of refueling stations, gasoline has roughly 120,000 across the U.S., where CNG has around 400. So that opens the door for policy to improve upon market conditions. And the policy's recommendations that I set forth have two goals: one is to incentivize infrastructure investment, and the other is to incentivize investment in the fuels and the vehicles.

And I don't have time to go into great detail in all of these, but hopefully during discussion the details will come out. The first is to encourage natural gas LDCs to price natural gas at a more efficient way in terms of the relation to retail

rates and economic costs. The second is to allow natural gas local distribution companies to open up their CNG stations, both existing and potential stations, open to the public and to include those costs into the rate base and provide the CNG at a cost of service basis. The third relates to LNG and would be to establish an industry consortia to investigate and coordinate investments in both LNG infrastructure and the vehicles.

The second set of policies relate, again, to vehicles and fuels. The first -- and I'll explain why methanol should be counted under something called the Renewable Fuel Standard during the discussion, but the first is to include methanol in the Renewable Fuel Standard requirements. The second is to mandate vehicle manufacturers to sell vehicles that can run -- be tri-flex fuel vehicles and run on both gasoline -- or all gasoline, ethanol, and methanol. The third, and I think the most important, is to rationalize the tax credit system for subsidies for alternative vehicles. And this is to base the subsidies on an

objective measure rather than -- which often ends up being a system of picking winners.

The third, or the final, is to streamline the retrofitting process for certification for switching existing vehicles from either gasoline and diesel to CNG and LNG.

And with that, I'll end. (Applause)

MR. GREENSTONE: Now we have Michael Levi.

MR. LEVI: Thank you. It's a very exciting first slide here. The more interesting one is the second. Each of us has one slide that, I think, encapsulates the situation that our policy proposal is intended to address. This slide shows you the evolution of natural gas prices in the United States, in Europe, and in Asia. What you'll see is that for a very long time these prices moved together and then all of a sudden, over the last few years, they blow apart. The lowest line is U.S. natural gas prices, which have dived deeper since the end of this time series. The highest line is Japanese import prices, which have actually gone higher since this graphs

ends.

Why? There are a few basic reasons. The first is that there has been a surge in supply in the Unites States. That has driven prices here down. The second is that there continue to be rigid pricing schemes in the rest of the world that connect natural gas prices to oil prices. But the third, if you look at this, is that there is not a lot of trade between the United States and the rest of the world.

The blue lines on this are liquefied natural gas trade. You see a decent amount between the Middle East and Asia. And within Asia you see some from the Middle East to Europe, as well. You see very little moving to the United States. That is in part because there was no reason to build infrastructure in the past, but also because you are not allowed to build infrastructure to export natural gas right now without receiving a permit.

That is why a series of companies have recently applied for permits to export liquefied natural gas from the United States and to build

terminals to do that. And this shows some of the permit applications. One has been approved, many more are pending, totaling around 12 billion cubic feet of natural gas a day. By way of context, the United States produces around 60 billion cubic feet of natural gas each day. Let me give you one more piece of context to understand how big this is.

World gas consumption is much larger than world liquefied natural gas trade, which is relatively underdeveloped. So when I say 12 billion cubic feet a day from the United States, that is relatively small in the U.S. context, quite small in the context of global consumption, but quite large in the context of global liquefied natural gas trade. So U.S. entering into that market could really, in principle, shake things up. The green bars are liquefied natural gas trade.

So a heated debate has emerged because currently, in order to export natural gas freely from the United States to countries with which we don't have specific free trade agreements that require us to

allow exports, you need to apply for permission from the Department of Energy and from the FERC. In order to export, we have a series of applications pending. The Department of Energy is considering them. Other parts of the U.S. Government are weighing in and lawmakers are deciding whether they want to intervene and perhaps change the rules.

One camp says, look, this is an opportunity to trade. Opportunities to trade are good. We should let it all go ahead. Why are we even having a discussion? There are a variety of other players that intervene on a series of fronts. Some involve classic externalities. The patterns of gas production and consumption affect climate change. There are externalities involved there. They affect the local environment. There are considerations that come into play on that front.

And if we're talking about the potential to put gas into the transport sector, they have implications for oil security, as well. There are also diverse specific interest on the part of

consumers who might have higher natural gas prices if we allowed exports from manufacturers who might have their landscape changed, as well.

The first part of my paper argues that we should be taking a holistic approach to assessing the wisdom and the appropriate strategy for natural gas exports. And the way to read this table is green is good, purple is bad, darker is more good or more bad. I won't go through all the pieces there except to highlight that the two big positives are the classic gains from trade. We are good at producing natural gas and other people want to buy it. You should expect that when you allow trade, you will benefit. And there are a lot of benefits on the trade and foreign policy front. In particular, constraining exports would hurt us on the trade and foreign policy front whether it's because we would basically be writing China's brief in its defense of rare earth export restrictions or because we would need to interfere substantially with NAFTA.

The downsides I will highlight, too. There

are problematic though mild distributional consequences, slightly higher bills for consumers, and we would see higher natural gas production which does increase the environmental risks that need to be dealt with.

So quickly to tick through the fine details of the proposal, we should be looking at this holistically, but we should approve exports because the costs do outweigh the benefits. We should be taking advantage of the fact that we are entering this market to make gains in ongoing trade negotiations, whether they are positive ones in the case of the Trans-Pacific Partnership Negotiations with Japan or defensive ones in the case of rare earth issues with China. We should build on LNG exports to improve global gas markets, and we should use the time that will intervene before we begin exports to strengthen environmental protections so that this is as much of a win-win as possible. Thank you. (Applause)

MR. GREENSTONE: Thank you, Michael. So part of the reason we were so excited to get both

Katie and Barry as discussants is that they can talk about all three proposals. So Katie, you get five minutes, as will Barry, to cover all three proposals. Tell us what's right and tell us what's wrong.

MS. McGINTY: Comprehensively.

MR. GREENSTONE: Yes.

MS. McGINTY: Don't start my time yet. Well, thank you, Michael, and good morning, everyone. Thanks for including me in this discussion. I wanted to start with this kind of thought which is, to me, it seems when it comes to shale, we can do shale smart or we can do shale not so smart. Right. So if we do shale smart, it's about job creation and it's about national security being enhanced. If we do shale not so smart, it's about communities disrupted and water quality adversely impacted. It's about bans that we have in some states today and in some countries in the world.

But here's the good news from my point of view, is that in between those two polar opposites are things that, to me, are not rocket science and that

some of the papers today point to. There are things like responsible leadership on the part of industry, technology that pushes continuous improvement, and Barry, yes, smart, appropriately balanced regulations, rules, and enforcement as between the states and the Feds. Put those things together and you move the dial towards the realization of the significant upside here.

But another thought I wanted to plant is the upside as we're looking at here in terms of energy, natural gas is also an incredibly valuable feedstock that could drive a resurgence in chemicals, pharmaceuticals, and advanced materials in the United States. And I guess if I had a concern, it's that we get so wrapped up in the are we going to/should we develop shale, should we regulate, should we not, that we fritter away potentially that big upside.

So what about the proposals? Well, congratulations to those who have written the papers and presented them. I think they're all good. I subscribed to them all. All right. But I don't think

that they move the dial that far.

So Lucas, let's talk about bonding. In Pennsylvania, we've got a $20 billion bill left over from 100 years ago of mining. The minerals went, the companies went, the money went, the bill and the mess are left. I'm for the updated bonding. Good idea. But I think it's true to say that having the money to clean up the mess is not the same as preventing the mess to begin with. Shale production is an industrial activity. There are environmental and safety issues. We got to manage them, folks.

So we have to have rules and regulations to protect air quality, protect water quality. We need safety regulations to ensure the proper cementing and casing and development of the wells. Why? So that that gas doesn't migrate and wind up in your drinking water; so that we don't have blowouts of wells. And as Mark Zoback, who's here, would say, so we don't inadvertently induce seismicity and cause damage. Bonding will not be so good an instrument in achieving those ends.

Second, the economic sustainability of the industry also depends on environmental continuous improvement. Why? In Pennsylvania, we have about 1,000 wells today. They represent 1 percent of the water consumption in this state. In 20 years, we're expected to have 100,000 wells. Well, shale is not going to get 100 percent of the water consumption in Pennsylvania. So the economic sustainability depends on continuous environmental improvement.

And the last thing I would just suggest to think about when you think of bonding, you might think, geez, it's those mom-and-pops, those smaller operators out there that we're most concerned about. But I think the market's going to say they're going to have the smallest bonding capacity. So you might have an issue there.

Chris, I'm all with you on the transportation. And I think you put a lot of good pieces of the puzzle together in terms of the infrastructure side, the vehicles, and the fuel. Here's my thought and concern, though, and I don't

know that you can do anything about it. If I'm the person deciding, am I going to plunk 100,000, 200-, $300,000 into changing my fleet, am I going to put the infrastructure in place to refuel that fleet? I'm worried about two things. Gas is a commodity. It's been cheap before and then it got expensive. I've been burned before. Even if you incent me on the infrastructure side, I'm worried about the fuel. And then even if I am optimistic about the forward curve of gas staying low, I'm looking at that forward curve of oil coming out of the Bakken with the shale oil. That's coming down. Not hugely, as you point out, but it's coming down and I'm thinking inertia, maybe I leave my fleet the way it is. Don't know what you can do about it, but that's my thought.

First thing, Michael, I think your paper's great. I'm with you. I'm mostly for a light touch. Let the market decide where the gas goes. But my thought about that I guess is it will be much ado maybe about not that much. And the reason is not that much -- we're not the only game in town. The shale

resources in the world are coming along, but Australia, Qatar, East Africa, LNG resources and infrastructure there; later China and India building their own shale capability.

So I end where I started. This stuff is good, it's important, directionally right. But I hope we don't miss the opportunity to seize the big brass ring, which is, to me, driving advanced manufacturing in the United States, chemicals, pharmaceuticals, and advanced materials with gas. Back to you.

MR. GREENSTONE: Now, Barry, in addition to -- thank you, Katie. (Applause) You were a model of efficiency and insight. Now, Barry, we definitely want your five minutes on the papers. But you also have to explain, what's going on with the Railroad Commission --

MR. SMITHERMAN: Right.

MR. GREENSTONE: -- and why you're here today.

MR. SMITHERMAN: Well, again, my name is Barry Smitherman. I'm the chairman of the Texas

Railroad Commission. The Texas Railroad Commission has nothing to do with railroads. We were created in 1891 by an act to the Texas Constitution. But when Spindletop came in, in the early 1900s in Beaumont, the state needed a regulatory authority to govern this brand new industry. The Railroad Commission was already in place and so the governor said let's give it to them. But the name has never changed.

To just give you some historical context, the state of Texas is the number one producer of oil. We are now producing 1.4 million barrels a day. That is more than every other country importing to the United States, except Saudi Arabia and Canada. So if we were an independent country, we would --

MR. GREENSTONE: That was settled before, right?

MR. SMITHERMAN: We would be the number three exporter to the rest of the United States. We also are the number one natural gas producer. We're at 17 BCF a day. That's down slightly, but only because of price. And we're the number five producer

of coal and we have more pipe than any other state. So that's the Texas Railroad Commission.

Again, I want to say thank you to the Hamilton Project for asking me to be here. We Texans don't get to California very much unless we're trying to steal, I mean, persuade jobs to come to Texas. (Laughter) And I do want to thank David for the backdrop that he established. That was a very good context for us to begin.

With regard to the proposals, I would be very cautious with the bonding proposal. First of all, there's no evidence that fracking contaminates freshwater. There's never been a recorded case. In fact, even Lisa Jackson, the EPA administrator, in testifying before the Congress has said on numerous occasions there's no evidence of that.

Plus, we have seen at least three cases -- one in Texas, one in Wyoming, one in Pennsylvania -- where the EPA has begun an investigation as to whether fracking contaminated freshwater, and their conclusions were no, that this was naturally occurring

methane. And I would also challenge the proposition that fracking is inherently more risky. Fracking is a process of injecting water, some sand, and a little bit of chemical, 5- to 7,000 feet below the surface, below generally an impervious cover. The risk is the same risk that we have in any drilling activity. It's completion. It's completing the well properly at the surface, particularly if that well has gone through a freshwater table.

Now, the way we like to approach bonding is we use bonding in Texas to make sure that when you've completed your drilling activity and the well is no longer productive, you take all your equipment off the space. And if you don't, then we will collect on your bond or we can fine you or we can pull your right to drill.

The other development that's happening is that most of the fracking is done by a handful of highly skilled companies: Schlumberger, Halliburton, Baker Hughes. And yes, while the operator of the rig may be a smaller independent, most of the fracking is

done by these companies. And these are some of the most technologically advanced companies. Every day they're refining this process to use less water, less potable water, less proppant, to frac quicker and to do it more safely. So I want to be careful going forward down this particular path. I appreciate the work.

Number two, with regard to using natural gas for transportation, yes, we need to strip away the impediments to doing this, including making it easier to convert your vehicle to run on natural gas and making it easier for the LDC to have you as a customer filling at your home. So a number of ideas that we could talk about there.

And with regard to the last proposal, yes, when we have prices in Asia that are a multiple of domestic prices, there's no way the market will sustain that difference. It would be great to be an exporting country of something. So if we have a lot of natural gas and the world wants it, we should go forward. (Applause)

MR. GREENSTONE: Thank you. So I thought we should start by giving the authors a chance to respond. Lucas, you went first. And what I can tell here is --

MR. DAVIS: And I got beat up the most.

MR. GREENSTONE: Yeah. What I was going to try and frame your remarks as, it's clear that not everyone thinks that when you write down an equation on the blackboard that that necessarily governs people's behavior. So I wondered if you could talk a little bit --

MR. DAVIS: Yeah, let me give a couple of responses. The first is that I really view bonding requirements as a complement, not a substitute, to traditional regulation, so I'm glad you brought up casing and cementing. I think you've got to have rules for how casing and cementing is done. I believe that if it's done well, it's very low risk. I'm not up here saying that it's risky, but I think you do need to have some teeth and this is where the bonding requirements come in.

The problem with regulating natural gas is that it's occurring at thousands of sites all over the U.S. You can't have regulators at all these sites. This is a hard thing to address with traditional regulation. And I actually think this uncertainty about risks is an argument for increasing these bonding requirements.

If it turns out that the EPA comes out with their big report in 2014 and it's categorically true that fracking is much safer than some people think it is, great, let's lower them. But in the meantime, this is a conservative approach to both, you know, working this resource, but also being safe about it.

One, is fracking more dangerous? Again, I think this is a tough question. You know, I think there's a lot of research being done on this. But it's deeper, which means it's higher pressure drilling operations with a higher risk of blowouts and you are using millions of gallons of chemically treated water. So handling that water just raises new risks that just aren't present with conventional drilling.

And the last little bit. I agree that there's certainly some fracking done by some major operators, but that figure that I showed is actually the well owners. It's not the drilling companies. So this is your Schlumberger.

It could be -- I haven't looked in Texas. It could be that there's a lot less -- you know, it's a higher degree of market concentration in Texas. But nationwide there's a lot of small and medium-sized companies doing fracking in the U.S.

MR. GREENSTONE: Thanks, Lucas. Chris, do you want to --

MR. KNITTEL: Just quickly, Katie brought up essentially the risk of converting your fleet to LNG or CNG. And certainly if you look at futures prices, the ratio that I graphed seems to level off about at four to one, so there's still quite a big benefit. But I think the heart of my proposal is really about the fact that the consumers in this market don't have enough incentive to convert to LNG or CNG because the consumers aren't getting the benefits from these

unpriced social costs, and that's why we need policy to intervene in this market.

And then third, actually most CNG light-duty vehicles and many medium-duty vehicles are actually bi-fuel vehicles where you have both a gas tank or diesel tank and a CNG tank. So you're naturally driving around a natural hedge, so to speak, of oil prices to natural gas prices.

MR. GREENSTONE: Chris, can you just expand a little bit on what the social cost might be? And --

MR. KNITTEL: Well, again, if we think about greenhouse gas benefits, local pollution benefits, macroeconomic benefits, and military benefits, all of those are lower for CNG and LNG relative to gasoline and diesel. And because the consumer is not getting the benefits of that that society's getting, they're not going to have the adequate incentive to shift their fleet over.

MR. GREENSTONE: And we don't have policies in place to price all of those or --

MR. KNITTEL: Well, ideally most economists

recommend taxes to equalize those social costs across fuels, but absent those Pigouvian taxes, they're often referred to, the gasoline petroleum-based fuels are going to have an unnatural advantage over natural gas fuels.

MR. GREENSTONE: Thanks.

MR. LEVI: So I agree that in the end when it comes to volumes of exports, this may be much ado about probably not nothing, but very little. I think if you work through the economics and the dynamics over this sort of 10-year-plus time scales that these things tend to evolve over, there's good reason to believe that most of the folks who've applied for permits will never build anything and may never export a drop.

That said, first, there are a lot of ways that you can do stupid things to try and forestall consequences you don't like of something that might not ever happen. So just because we might not end up exporting a lot of natural gas does not mean that we cannot do a lot of damage to our trade arrangements

that we generally benefit from, particularly in the energy space, well before that works itself out.

Second, there is a lot of natural gas that will come on-stream from elsewhere. Some of those producers are substantially lower cost producers found in the United States. In order to compete with U.S. natural gas, though, they may have to start moving away from the way they price gas right now, which is by linking it to oil prices in often fairly opaque arrangements that have a lot of political content to them. That causes problems in international politics. And to the extent that the United States can provide some stimulus to move into a more market-based global system, that can be valuable.

Last piece to flag is that because others want the opportunity to access U.S. natural gas exports, we have the opportunity to have some new leverage in trade negotiations. Again, whether we actually end up exporting a little or a lot may not be that material to that. When you go to Tokyo and talk to people about trade negotiations, they want to know

whether if they do a deal on the Trans-Pacific Partnership, they will get preferential access to U.S. natural gas. It is a nice thing to have a negotiating card when we're involved in international trade negotiations that would open up markets to a wide range of U.S. goods and services.

MR. GREENSTONE: Thanks, Michael. Before we leave your topic, I wanted to just turn to Lucas, who I had talked to briefly before we had this panel, and ask Lucas, I thought we believe in free trade. Why are people even talking about it? And you know, actually, I heard in between Katie's remarkable remarks some threads of, well, we should save the natural gas here and have, you know, chemical industries and all kinds of things like that in the United States. Do you agree with that.

MR. DAVIS: Exactly. I share this response. I believe in gains to trade. I think of, you know, both in goods and services, I think, for example, of U.S. law firms have a lot of service with international clients. And it's probably true, if we

said that they can't deal with their international clients, it's probably true that the price of those services would go down. But that just strikes me as just nuts, right? There are gains from trade in services and goods.

So you actually mentioned that some response to this is just, you know, why are we talking about this to begin with? And what is the response to that? Well, do you want my response to that?

MR. SMITHERMAN: Yeah, I think if you are concerned that we're actually going to run out of natural gas or that the price ticks up very highly if we begin to do this, then you would be opposed to it. But I think what we're going to find is we have more natural gas than we believe we do. So whether it's 100 years or 200 years -- for example, the University of Texas working with the Sloan Foundation has some preliminary findings that the gas available in the Barnette Shale -- now that's Dallas, Fort Worth -- just the Barnette Shale we've recovered since the beginning, over 25 years, 10 TCF of gas. They believe

with a modest increase in price that there's at least that much more gas still remaining in the ground, if not double or triple that amount. That's just one basin.

So the reality is, depending on price, we've got a lot of gas. And if we're only going to move 6 or 7 or 10 BCF a day in exporting, you know -- heck, in Texas we produce 17 a day today -- I just don't think it's going to have a big effect on price.

MS. McGINTY: So I feel like I need some clarifying remarks. So Michael, one of the things that I did want to say is, look, DOE has a role under law that they're obliged to play here. I think they would be well-served to follow the kinds of approach that you're talking about: transparent, direct, out in the open, here's how we're going to decide the question as to what's in the public interest as compared to what I fear is unfolding, which is a, look, we think it will inflame passions if we're issuing all these licenses to exports, so we're going to jury-rig some of that. Not a good way to go.

And I do want to say, too, yeah, I'd like to see us get as much value added opportunity from this gas resource as we possibly can. Do I think we should get there by jury-rigging the export system? No. But do I think that we as a country can find ways to make it more rather than less attractive for businesses to do business in the United States? Yes. I'm talking about putting our heads around making it attractive, chemical, pharmaceuticals, advanced materials, to do business in the United States and grow those industries for this and future generations as an economic powerhouse.

MR. LEVI: Can I pick up briefly on the basic question? I think the answer, in principle, open trade is fantastic. You have externalities here that you need to think about. In principle, you price those externalities, allow open trade, and everything works out. In practice, you don't necessarily price those externalities or regulate them.

And the second is international trade is a strategic game. The decisions you make affect the

decisions that others make and that affects U.S. economic opportunities.

Let me flag one small thing on the manufacturing front. I think it's important to remember when you think about exports that there are two impacts on manufacturing for allowing exports. One is you have marginally higher prices for feed stocks. That's a penalty to manufacturers. But the other side is there's a lot of manufactured input into natural gas production. Okay? There's a lot of capital spending. About 20 percent of that goes to steel, about 10 percent of it goes to cement. If you are increasing U.S. supply of natural gas in part to serve export markets, you are going to also increase demand for manufactured products. So you need to look at both sides of that equation when you think about the ultimate impact.

MR. GREENSTONE: I wonder if we could turn to Lucas' bonding proposal for a minute, and I wanted to pick on something you said, Barry. It's probably completely unfair, but I think you thought, well,

gosh, we don't really need this. We have good industry standards. Katie was part of the DOE group that put together some industry standards. Why do we need to bother with all this bonding? And so I guess I want to say, well, why don't we need to?

Maybe it's not true in Texas, but there are signs over the rest of country and the world of great unease about fracking, justified or not. And I think there's a potential that we will have this wonderful opportunity that, in principle, we're not going to be able to completely take advantage of.

MR. SMITHERMAN: Well, first of all, I think we would do better to focus on education and disclosure. For example, we were one of the first states, if not the first, to pass a frac fluid disclosure rule which requires the operators to disclose all the chemicals, all the proppant, all the water. And in fact, that came after a voluntary program, that's fracfocus.org, where the Groundwater Conservation Council, working with the Interstate Oil and Gas Compact Commission, put this website in place.

And I think Colorado was either right before us or right after us and a number of other states have followed suit.

So sunshine, I think, is always the best antiseptic. I just want to be careful about taking capital out of productive activities and putting it aside for an alleged problem, which I really don't think exists.

MR. GREENSTONE: Lucas, could you talk a little bit about blanket bonds --

MR. DAVIS: Yeah.

MR. GREENSTONE: -- since not everyone knows what they are?

MR. DAVIS: I will, but let me also just respond just really quickly to Barry. I mean, the reason I like bonds is that if everything goes well, the companies get the money back with interest. And I think it is -- and I am in the proposal. I'm very upfront about -- you've highlighted there is a cost to this. You're telling companies that they have to take some of this money away from an investment and put it

into a bond. And I think, hey, look, this is not a panacea. That is an economic cost. But you've got to put it into perspective. And the bond amounts that I'm proposing, including eliminating the blanket bonds, would put about $200 million annually into bonds. That's not a tiny number, but that's got to be compared to a $100 billion annual natural gas market. So this is not a giant. This is just pretty small compared to the size of the market.

On blanket bonds, yeah, I didn't -- seven minutes is not enough time to think about this. But under the current regulations, the way it works is that you can either go along and do bonds kind of well by well or you can take out a single statewide or national blanket bond which allows you to do as much drilling as you want either within a state or nationwide. And the problem with that is that there's a lot of wells. Every year in the U.S., there's about 20,000 natural gas development wells that are drilled.

So even though they're pretty small companies, you're talking about many companies have

hundreds of wells. So what this means is that the average bond amount per well ends up becoming very small with these blanket bonds and you have -- and we have had -- what has happened in the past is that you have a company that goes bankrupt that has 300 uncapped wells, then all of a sudden that's left on the public role to plug and cleanup.

I'm glad you mentioned that Texas sees these bonds as a way -- primarily as a tool for reclaiming sites. I think that's great. In fact, I think in the sense that this proposal's a no-brainer, you can embrace it simply on that perspective. Let's just put this money aside so you can plug wells and reclaim sites. The current bond amount is too small even for that.

MR. GREENSTONE: Okay. I think Katie had one comment about the state of science on fracking influence in water quality?

MS. McGINTY: So Barry shared an insight, which is an important one, that fracking has never been shown or demonstrated to pollute water, and that

is true. Although I do worry about how you phrase these things because it invites the public's skepticism, concern, it inflames some of the opposition, I think, because it is technically true to say -- it is absolutely true to say fracturing fluids have not contaminated drinking water. But it is absolutely the case that improperly developed wells in a fractured gas field have contaminated drinking water. The situation in Pennsylvania, for example, was that the geology was not understood, the well was not properly cased and cemented, and, yes, actually it was not biogenic gas, it was Devonian gas that was released and did get into drinking water.

Now the problem was solved. The wells were recased. But I think it's helpful to be specific so that the public's trust and confidence that they know the deal and want to see the industry proceed, I just think that's important.

MR. SMITHERMAN: Yeah, we could probably have a long conversation about this. We could have a long conversation, but the cases that I'm familiar

with, whether it's Texas, Wyoming, or Pennsylvania, the methane that found its way into drinking water was naturally occurring. Methane has an identification and a marker and this came from a different era, a different formation, and not from the fracking activity. Now, we've done not a good job of communicating that and we need to work on that, no doubt about it. We need to do the best we can.

Can I quickly say something about transportation? You know, David showed that we have very little optionality on fuels when it comes to transportation. But you think about into every home, at least in Texas, you've got a water pipe, cable TV, electricity, and you've got natural gas. So the ability to have this at your home is already there. And most of the gas distribution companies are regulated by the local utility commissions, and it's just a question of establishing the correct rate structure to incent this to go forward, stripping away the impediments. I think we can get this done. And if you look at 18-wheelers, for example, it's actually

much better on the engine and they have the ability to drive it a long time, which in this economy is better for the owner of that tractor.

MR. GREENSTONE: So thank you for making that transition. I was going to ask Chris, I think everyone here is dying for the scintillating topic of how to price natural gas correctly. But I know that that's central to Chris' proposal. So Chris, do you want to talk a little bit about that and what some of the impediments are?

MR. KNITTEL: Well, so current retail natural gas prices at the home are about 50 percent above what it costs the utility on an incremental cost basis. And that puts natural gas -- refilling your CNG vehicle at home at a huge disadvantage.

MR. GREENSTONE: But why is that?

MR. KNITTEL: Well, so there's a markup. Most utilities have a markup to recover the fixed cost associated with selling with either electricity or natural gas. What I propose is not getting rid of that markup per se, but to provide a rate structure

where consumers can pay a lump sum, monthly, fixed cost that would give them access to the preferential rates that they could use for their CNG vehicles. So the fixed cost would allow the utilities to recoup their capital cost for their infrastructure.

And that's similar in nature to the preferential electricity rates that we often hear about for electric vehicles and would provide the correct incentives for the home to trade off whether refilling at home versus refueling stations. You can refill in the garage. The apparati that you would use are slightly more expensive than a 220 outlet. But for $4,000 you could install something known as Phil, P-H-I-L, in your garage and refill your CNG vehicles at home much faster than you would an electric vehicle.

MR. GREENSTONE: Okay. We've got, I think, 90 seconds until we're going to go to questions from the floor. And in these 90 seconds we are going to resolve what I think is the crucial question. Is this natural gas stuff the blue bridge to the green future

or are renewables and low carbon fuel sources a thing of the next century because of natural gas? So who wants to solve that one in the 90 seconds?

MR. SMITHERMAN: I would say it's a very long bridge. I don't know what's on the other side, but probably not in my lifetime will we run out of natural gas and it be reasonably priced.

MR. GREENSTONE: And did you think that three years ago? Four years ago?

MR. SMITHERMAN: No. No. But now it's driven by technology. It's not that we don't know that we the resource. We do. And technology, good old American know-how, continues to allow us to get more and more of it up.

MR. GREENSTONE: Does anyone else want to join in on that?

MR. KNITTEL: Well, I just want to say -- so one thing that -- you know, the audience might come back and say with respect to transportation that the highest value use of natural gas is in electricity, and I think that could be true. But in terms of the

blue bridge to the green future, the big concern for greenhouse gas emissions is that we replace all of our coal-fired power plants with natural gas-fired power plants and then that coal gets exported to China or elsewhere. So I think we have to keep in mind the international trade implications of all of the policies with respect to how they relate to the environment.

MS. McGINTY: Yeah, Michael, I'd just say that, you know, the market -- the marketable work -- there'll be new demands in the marketplace, especially as gas is cheap, whether it's from transportation. We're seeing a very significant shift already in generation from coal to gas, as David pointed out. That's happened in very rapid fashion. Do those factors plus some export, et cetera, begin to affect that forward curve on gas so that you have enough uplift that you can finance renewable energy projects?

I think there's enough dynamism in the market where you could see that, but I think it's impossible not to see right now, today. It's really

hard to finance utility scale renewables with the demand and where the price points are today.

MR. GREENSTONE: So I think we're very fortunate -- thank you, Katie. We're very fortunate for the next panel, I think, because actually we're just touching upon these issues, but in the next panel Hemant is going to solve this question, I believe.

MS. McGINTY: They're figuring it out.

MR. GREENSTONE: Okay. So let's open the floor to questions.

SPEAKER: Great panel. Thank you very much. I have two things that you guys didn't mention that I'd like your comments on. One is that there have been some calculations now that the fugitive emissions related to bringing gas into the transportation industry are going to completely negate any climate benefit whatsoever. And the second is that although fracking in a new reservoir may be a very controllable and safe activity, that these are often being done in old reservoirs where there are lots of abandoned orphan wells; wells completed before there were

regulation. And it's really those wells that represent the risk. So I'd like your comments on those two things.

MR. KNITTEL: So I think you're referring to the recent PNAS paper that looked at transportation. There's two responses to that. First, -- well three. Because first, that's a very important issue, just how large these fugitive emissions are. There's, as you might imagine, quite a bit of controversy as to how large they are. The PNAS paper used, I think, 2.4 percent.

Industry has come back and said, well, that's based on data for very old wells and very old data and the fugitive emissions are probably closer to under 1 percent. I think the response really misses -- the critical issue is, how costly it is to get rid of the fugitive emissions, and that might be totally unrelated to how large they are currently. I think fugitive emissions can be -- certainly need to be regulated more. It might be the case that it's very easy to seal the wells or seal the pipelines. That's

what we need to have a better handle on, is how costly it is to reduce them.

MS. McGINTY: I just wanted to share that at least one big piece of the greenhouse gas equation with respect to shale methane is at the time of well completion. And I think the new EPA regulations requiring the green completions not having a venting of that initial burst of gas from the well will take a significant chunk of that piece of the greenhouse gas equation out and put the gas into productive use.

On your question about old fields, that is part of the situational challenge in Pennsylvania, the reason why the casing and cementing in the wells are so important. What happened in the situations that have been reported is exactly that the well wasn't properly cased and supported. The gas migrated into those old developed channels and into water resources.

MR. GREENSTONE: Okay.

MR. LEVI: So I have one small more thing on this question of fugitive emissions and transport. It's also important to keep in mind that the study

that has created this interest assumed that there was a 20 percent efficiency penalty when you switched from a conventional car to a natural gas car. So that reflects old bus conversions, but is not necessarily reflective of the current available technologies.

MR. GREENSTONE: Okay. I think Charlie had a question here.

SPEAKER: Thanks. Lucas, you haven't been picked on enough, so let me just ask you a question about your bonding. You pointed out that one of the problems you're trying to solve is that some environmental consequences may not emerge for a long time. And I wouldn't think that bonds would really address that, because somebody's not going to leave a bond sitting at the bonding agency for 10 or 20 or 30 years.

MR. DAVIS: Yeah. No, that's exactly how it works. You have to -- the bond is posted until you complete production on the well. So that's, in many cases, decades after you've actually constructed the well.

SPEAKER: The question really I have, though, is have you looked at drawing on experience in hazardous waste and other areas, other kinds of ways of reforming the liability rules to deal with this such as (inaudible) liability?

MR. DAVIS: I mean, I think the hazardous waste provides great motivation for this. You look at the Superfund program, we've spent $35 billion cleaning up hazardous waste sites. You know, what we want to avoid here is having a bunch of expensive sites that we don't have any funds available to clean them up. What we're trying to avoid is a Superfund kind of scenario.

MR. GREENSTONE: Okay, in the back? Yeah.

MR. SMITHERMAN: While he's going -- but let me just --

MR. GREENSTONE: Yeah.

MR. SMITHERMAN: So in Texas, we have an industry-funded cleanup fund that is dedicated for plugging abandoned and orphaned wells. So every year, we have a queue of how many to work off and we work

them off every day, and it seems to be working pretty well. The industry understands that they need to be responsible. If an operator goes out of business and leaves an abandoned well, we go in and plug it.

SPEAKER: Hi. I work in the renewable technology sector, Cleantech. And there's no question that this new gold rush is killing renewable, and so that's just a brief comment.

But I wanted to talk about the bonding and the whole issue of remediation and environmental controls. It's really interesting. The new technology -- and we're just starting to learn what's actually in the secret sauce. It's great that Texas has regulations like that. But a lot of places, we don't know what chemicals are actually being injected. And we're just starting to do some studies and something that -- new technologies are being deployed on a massive scale.

And you know, we've heard this before, that the new technologies, they're benign. We'll disclose everything. Things are going to be great. And then

later on we find that we're left with a huge mess.

Interesting, there was just a case decided about this whole remediation program for, you know, nuclear fuel and what are we going to do with all this nuclear fuel, the 70,000 or I forget how many pounds or tons or whatever that we have stockpiled. So I'd like to hear some more comments about that. Do we really know what's going on environmentally? Don't we need to take some more time to figure this out and before we go madly forward with this new gold rush, not to mention the ideas of subsidizing that gold rush, as well?

MR. SMITHERMAN: So let me just address this. Disclosure is great and I think we need to have more of it. But let's remember that the companies are incented to use less water, less chemicals, less proppant. And in fact, the biggest component in the chemicals for most of them is guar, which is a bean. So they import that. And they're trying to get away from chemicals that cost more or that have a half-life that's too long and use less proppant. So we're

moving away from freshwater to brackish water. We're moving toward recycling water, using less sand, using less chemicals, all because it allows the economics of the well to be better.

There's no replacement for disclosure. I completely agree with that. But I think you'd be surprised at how the industry is working to reduce the use of all of those elements that go down hole.

MS. McGINTY: Yeah, I mean, my sense is that the issues are knowable and they are manageable. But one of the things that I think is of concern, especially in these days of constricted state budgets is do you have the boots on the ground to ensure that the best management practices are being followed, to ensure that the resources are not being adversely impacted?

And the situation there is a tough one because to the extent the state has money to put to their oil and gas program, the draw is to hire staff to process the thousands of permit applications that are coming in, not to put the dollars towards

necessarily the boots on the ground. So I do think we need to do some rate sizing of our investment, again, to ensure that the industry can thrive over the long haul and we won't have an oops that sets the industry back.

MR. GREENSTONE: Okay. I think we have time for one final question.

SPEAKER: I just wanted to set the record straight on Chairman Smitherman's behalf. By the way, he presided over the substantial expansion of the wind industry in Texas when he was chairman of the Public Utility Commission and also the largest investment in transmission in the United States in order to bring that wind energy to market. Texas, of course, is the largest wind producer by a substantial margin. But I also wanted to come back on the bonding question one last time.

There was a comment that, well, if it turns out that there's no problem, the companies will get the bond back. My understanding of the bonding business is that the company that issue those bonds

charge premiums and those premiums are not returned. So it seems to me that we're imposing a cost in the absence of evidence of harm that may not be appropriate. Perhaps we first should look for harm.

MR. DAVIS: On a federal legislation, there's two different kinds of bonds: there's a cash bond or a surety bond. You're thinking of -- and you're right, with the surety bond you're going to a third party where it looks more like an insurance policy. And you're exactly right, in that case you're making a payment and you're not going to see that back.

Under a cash bond situation, it's close to the way I described it, where this is your money, it's gathering interest during the decades in which the bond's sitting there, and you get it back at the end. I just -- I've got to go back to, yes, it's a cost, but it's a modest amount of cost. And given the amount of uncertainty about environmental costs today, I think it's a cost worth paying.

MR. GREENSTONE: Let me just say, when I

asked Lucas to write this paper, we were very good friends and I hope we'll be able to see ourselves -- this relationship through today. But I do think it's a wonderful proposal, Lucas, and important. Could all of you join me in thanking this incredible panel?

(Applause)

**ROUNDTABLE: INVESTING IN CLEAN ENERGY INNOVATION:**

**Moderator:**

HEMANT TANEJA
Managing Director, General Catalyst Partners
Co-Founder, Advanced Energy Economy

**Panelists:**

SALLY M. BENSON
Director
Global Climate and Energy Project, Stanford University

KENNETH A. HERSH
Co-Founder and Chief Executive Officer
NGP Energy Capital Management

VINOD KHOSLA
Khosla Ventures
Former Chairman and Chief Executive Officer
Sun Microsystems

JAMES E. ROGERS
Chairman, President and Chief Executive Officer
Duke Energy

MR. TANEJA: Thank you, Secretary. So, the title of our panel is “Investing in Clean Energy Innovation” but if you listen to Michael’s panel, it would be about divesting clean energy innovation. What we want to do in this conversation is focus on the last eight to ten years where we have been

investing actively in this space, things that we have learned, look at the trends in terms of the kinds of things that are starting to show promise, and then shift the conversation into, what does all of this mean in the context of natural gas, which is obviously an elephant in the room.

Just to quickly introduce the panelists, we have Vinod Khosla, who is the founding partner of Khosla Ventures, and Vinod has been a real force of nature in this space making significant bets on truly transformational technologies.

He’s got a very diverse portfolio, and one of the points he was making to me earlier was that we need to make sure we don’t define renewables in too narrow a context. This is a very broad set of applications when we think about the technology applications in this space.

Next we have Jim Rogers. Jim is the chairman and CEO of Duke Energy, and he looks a little less stressed after last week now that the merger has been approved.

Jim's got the largest utility with about 60,000 megawatts and seven million members -- customers, and he has been a real advocate of efficiency and renewables and I'm hoping he can give us some perspective on just where exactly we are when it comes to scale in the adoption of these new technologies as well.

Next, I have Sally Benson. Sally is at Stanford and she's the director of Global Climate and Energy Project, and as I've gotten to know a bit about the work that they're doing here, it's interesting, it reflects a lot on how we have tried to commercialize science in the past decade in this space and leveraging a lot of learnings from there and doing things right.

And some of that will come out as we start to think about the role of strategic partners in bringing university technologies to market.

And, finally, we have Ken Hersh. Ken is the CEO of NGP Energy Capital Management, and he's been investing in this general space around natural

resources for over 30 years, and the firm has got a portfolio of about $10 billion in assets. So, I'm very keen on getting your perspective on how you have looked at the clean energy investing over the last decade, how you've participated in it, and how you think about it going forward.

So, let me start with the first question. So, this is a sector where, for every type of technology, there has been multiple different versions that have been funded -- 200 companies in solar, dozens in wind, dozens in biofuels and biochemical-type technology companies -- and it's pretty obvious that this is not a space where you get a large number of winners.

So, part of what we all knew as we got into this space was failures were just going to be part of the process, and we are seeing a lot of failures, the most notable one being Solyndra, which, you know, we never complained when the first space shuttle crashed and we lost half a billion dollars, we make a big deal out of losing $500 million in trying to commercialize

Solyndra, which, if at scale it worked, it could have been very impactful.

So, in my view, I think we have to not dwell on failures in this particular conversation. So, what I would ask you is, what are the things that are starting to look like they will be the emerging technologies that truly can have impact, truly can generate returns and become large companies of the future? What's working?

MR. KHOSLA: Thanks, Hemant. Can everyone hear me? Good. I speak loud.

You know, the thing about technology is most people have been making investments in incremental technology. To me, they have always felt like sure shot bets to lose. Almost certainly, either you'll really win big or lose, but there's no such thing as winning small in any of the major markets. In the minor markets, there is. And the reason is very simple, all the incremental bets have said, there's a renewable here, I'll compete with a renewable with an incrementally better technology. That market lasts as

long as the renewable market lasts.

I think if you look at the presentations I gave five years ago I said, we don't invest in clean tech. My slide shows, if anybody's seen it, and I think I've spoken to many groups like this, we invest in main tech. This is mainstream technologies that compete on the basis of unsubsidized market competitiveness.

If you place those bets and you're successful in developing the technologies, then you're in good shape independent of what the press says or what pundits say.

Things like Solyndra are a natural part of technology development. If you have ten major solar efforts, almost certainly, seven of them will fail. There will be a win, place, and show, and everybody else will be a loser. So, one loser doesn't constitute proof that it doesn't work, it's just part of good capitalism.

So, to give you very, very specific examples, I'm really excited we have three spanking

new facilities, large manufacturing plants, 300,000 square feet type facilities coming up in Mississippi in the next three months. One's a biofuels facility called KiOR, market comparative, we think, with deep offshore drilling, with or without the fact that it's in the U.S. or in some other part of the world which doesn't have any subsidies. That's coming up. It's a public company. They announced public completion of a $200 million facility last month, I think, and they're bringing out the facility. Amazing facility.

We have a new solar facility built in the U.S., just funded, coming up now, actually starting shipments. We have a brand new electro-chromic glass facility just coming up in Mississippi, 300,000 square foot factory to make six-foot by ten-foot pieces of glass, which if you buy at the price at which they sell them, you save enough on building air conditioning and drapes and blinds, such that you're cost-neutral day one, before you start operating and you have continued efficiencies.

Those are examples of economics. We have a

lab coming up in Fremont that's making MR-16 lamps, LED lamps. Average payback period if you're a low -- if you pay a low cost for electricity, like 12 cents a kilowatt-hour, is less than a year. If you pay, like most retailers do in New York or San Francisco, 20, 25 cents, then the payback period is months, a few months, and these are no compromise lights.

And so, I could give you a dozen more examples. In energy storage, we're doing compressed air storage where we're not competing with renewables, we're competing with gas speaker plants in cost of power. We are competing with building additional grid transmission in the cost of grid transmission.

So, those are mainstream markets. Navistar has announced they're adapting a new engine, working with us, that doesn't cost much more but is 50 percent more efficient for trucking, which is a mainstream application. Nobody buys renewables in the trucking market.

So, that's sort of my perspective. I could go on and on, give you ten more examples just like

that.

MR. TANEJA: That's great. Ken, what's your perspective? You mentioned to me earlier that you have started to -- over the last few years, you did invest in the clean energy technologies although your broader target has been around natural resources. What have you learned? How do you think about it going forward?

MR. HERSH: The best thing -- the best results that I've had from investing in energy technology have been not investing in energy technology. I started in the industry focused almost exclusively on the upstream oil and gas business, and we've seen the cyclicality in the business. And I don't want anyone to ever underestimate the power of the cycles I the business.

So, I learned very early on, from an energy technology standpoint, to really focus on a couple of things. Number one is, never, ever invest upon a reliance on a government policy, okay. If you think about what happens in energy technology where you're

taking technology risk to make the product, you're taking adoption risk, can you sell the product, and then you have scale and execution risk -- can you actually get it to a point where your cost of production comes down and you make an impact?

Over a reasonable period of time, that may take seven to ten years, and then full execution is a 30-year project. There has not been an instance in the federal government or state government where policy has stayed constant for even a fraction of that time. So, don't think for a minute that there isn't cyclicality in policy.

You know, my expression is, the government always shoots behind the target, okay, and that's essentially what happens, because they're interested in putting out yesterday's fire. So, number one is, don't rely upon the government. Number two is, don't ever rely upon investing based upon price relationships.

Okay, now we heard an example this morning of price relationships, oil versus gas, because those

can change and they wildly change. In the late ‘70s, we were debating -- we were implementing law that says we should not use natural gas for power generation in this country because it’s too vital for heating, okay. Things change here very, very dramatically and if you look at price relationships and you look at what happens on the back side of the demand curve, those relationships will go away.

Don’t think for a minute that if we have a significant change in either fuel efficiency or a new product that takes a dent out of gasoline or diesel, that if we took the nine million barrels a day that the United States uses on gasoline today and if we cut it by, say, 15 or 20 percent and we decreased global oil demand by two million barrels a day, the price of oil would go to $50 and gasoline would be at two bucks. Now, all the sudden that price relationship could be quite dramatic.

If 10 percent of the U.S. cars were on natural gas -- powered, you’d use 20 percent of the United States’ natural gas supply. Don’t think that

the price of natural gas would stay low. Those are the examples of understanding the full cycle movement of pricing. So, you can't rely upon the relationship.

It's a commodity. If you're investing in commodity, it's a doggy business and so you want to be the cheapest dog in the yard. That's what it is. It's about the unit cost of production and can you make a competitive product.

And then, finally, don't underestimate the response of the incumbents, and if you have an industry -- and Vinod's done a phenomenal job of talking about ways to reduce our reliance upon oil for fuels -- for transportation fuels. Don't think for a minute that there isn't an entire industry of incumbents who are working on that exact same question and their competitive response to it, and when you have installed capacity, you can drive your price way down because you've already sunk the major capital.

So, those are the examples that elongate the adoption risk, elongate the technical risk, and in my opinion, have made it not a great reward given the

risk to undertake. So, we've focused on energy efficiency, we focus on things where it makes an immediate impact, and that is something I can get my hands around. But trying to be a long-term prognosticator is too difficult.

MR. TANEJA: Ken, you bring up a good point. It's hard for these energy technology companies to get to scale and really have an impact in any kind of a meaningful fashion without partnerships with the incumbents, who are either developing competitive responses or they can get behind them.

Sally, you guys have been operating on that particular vision at the Project at Stanford, and I would love to get your thoughts on how you think the process of bringing innovation going forward, A, requires the partnership with these strategic partners, and how that will translate into the next generation companies.

MS. BENSON: Sure. So, as a perspective -- as a technology developer, so, I think the first thing that people didn't realize is that energy technologies

take a really long time to develop. It was 1954 when we discovered the photovoltaic, you know, here we are 2012, maybe by 2015, 2020, we can reach grid parity for a wide, you know, set of the electricity consumers and so forth, so that's a long time period.

It was 1888 when we had the first wind turbine generating electricity with 400 batteries out in Ohio, okay, and now here, you know, wind as we saw today is very, very competitive. That's a really long time.

So, we have to deal with that issue, and in part it's because the electricity system we have today is absolutely remarkable. It offers a very high quality product at a very, very low cost with a high degree of reliability. It's hard to break into something that's so highly refined and honed. So, I think that's one issue we have to deal with.

Another one is if we think about the technology development pathways, it's very fragmented, you know, ideas often start at a Bell Labs or at a university, then you need to hand off to somebody who

can turn that into a real product, then you need to get the capital to really invest in the factory, so very fragmented process and because of this fragmentation, you can have technologies stall, which is what I think we've seen a lot of.

So, I'd like to bring us now then to our project, the Global Climate and Energy Project at Stanford, which is really an incredibly unique model. Five companies came together about a decade ago, Exxon Mobile, GE, Toyota, and recently -- and Schlumberger, and we've recently added DuPont, to work to address both of these issues. One is recognizing it takes a long time, so we work on technologies that might have application in the 10 to 50 year time horizon, so we recognize it right up front.

And then the second issue we deal with is the fragmentation. So, what we do is we involve the major technology providers, resource providers, at a very, very early stage in the development cycle, so our goal is to work together to have the right people working on the right technologies with the right set

of partners so at the right time we're able to advance those into the marketplace in a way that avoids the stalls and failures and so forth.

So, that's our approach. We're ten years in, we have a lot of fantastic technology successes, we have world record organic photovoltaics, we have world record on thin film amorphous silica, we have single cycle combustion efficiency of greater than 65. So, there are many, many successes and we're still at the early stage of nurturing those to commercial products, but that kind of partnership, I believe, has great promise for the future of energy technologies.

MR. TANEJA: Jim, almost all renewable energy and efficiency companies want to come talk to you because they know you're the channel to market and the business doesn't get built unless we can align, somehow, with your business model. You've been a huge advocate of the innovation in this space. How has renewable energy, energy efficiency, become part of your business model? How do you see it getting to scale and actually become a relevant line in your

overall business?

MR. ROGERS: That's a tough question. I would simply start by saying, when our industry began in the early 1900s, we were a high tech industry of that time. I know you all are sitting there saying, right. But the reality is we were on the road to provide universal access to all consumers in the United States, and in the 20th century we did it, we had a business model, we had a regulatory model that really allowed us to do that.

And we did it in a way, unlike the transport sector, which is dependent on one fuel, oil, where our dependency is really on a portfolio of renewables -- wind and solar, nuclear, natural gas, coal, and the fifth fuel, energy efficiency.

So, we have developed a model, but the challenge -- and to answer your question -- the challenge really centers around the fact that we have to remake our generation fleet in the next 40 years. We're going to retire and replace every power plant we own today with the exception of our hydro facilities,

and that assumes we don't extend the license on our nuclear plants from 60 to 80 years.

So, in a sense, think about it, we have a virtual blank sheet of paper to design what the energy generation fleet will look like in the future.

Secondly, we're going to have to, for cyber security reasons and other reasons, really start to rethink the grid in a different way. Now, you will not hear me use the phrase smart grid, because it's a concept that's been over sold and over hyped, and actually has turned out to be an impediment to the adoption of new technologies.

So, knowing this challenge is in front of us, new business model, new regulatory compact, new technologies to be deployed, what do we do? We're not going to be one of these incumbents that fights it; we're going to get ahead of it. I mean, I used to practice law in Washington with Bob Strauss and he used to have a great expression, when a parade forms on an issue that's against your interest, you have two choices: you can throw your body in front of it, let

them walk over you, or you can jump in front of the parade and pretend it's yours.

So, on clean tech, it's my parade.

(Laughter)

Now, let me tell you how I'm going about it real quickly. First of all, I'd say this, it is important to note that we have looked at 700 technologies in a funnel system over the last four years, and in the course of that, we've adopted some technologies. Today, in our system, we have 20 in the labs -- that's a long conversation -- we have 27 pilot projects going on in our system, we're engaged with EPRI, we're engaged in 63 different pilots that are going on outside our system and around the country, and maybe the single most important thing we're doing is we're part of the U.S.-China Clean Energy Research Center.

We have MOUs with seven Chinese companies, because I believe that the Chinese have the ability to create the intellectual property of scaling technologies. Use one example, nuclear. They're

building five AP1000s will be built before we have to start retiring and replacing our nuclear fleet in the United States. There will be a lot of learning with respect to that.

We're looking -- nuclear is just one area, but if you look at home energy management systems, we're piloting four different ones to see which one works the best. We're using various technologies to improve our grid. Because I actually think, in the longer-term, that we'll move more toward a micro grid approach to the design because of cyber security concerns, and that in itself is a longer conversation.

The important point here is, four years ago, we didn't own any wind or solar. Today we have 1800 megawatts where we have built and sold. Today we have seven different battery technologies that we're testing. We have a project in Texas, there are no trees, and if you were there you'd understand why we called it "No Trees", wind farm where we're using battery technology there, and different battery technologies at our substations, at our transformers,

and in our generating sites.

So, we believe we're going to reinvent our business, we're going to adopt new technologies, and when you look at our company four decades from now, we'll look fundamentally different than what we look like today.

MR. TANEJA: My next question is first for Sally and then for Jim as the academic and the practitioner. When you think about natural gas, how much of it do we really have? And what is the best use of this precious resource in your opinion?

MS. BENSON: Okay, so how much we have, if I knew that, I probably wouldn't be sitting here. So, I really don't know. You know, forecasts are that by 2035 it's very reasonable to expect that our overall in the U.S. natural gas production will increase by about 30 percent compared to today. So, that kind of provides a benchmark.

So, I will say, I agree that natural gas is a very precious resource and so let me say why, number one is, today we have technology where we can generate

electricity with 60 percent efficiency, that's off-the-shelf technology. In the future we're heading to 65. So, very efficiently, that's about twice as efficient as today's fleet of power plants that are generating electricity.

Second, if we carefully handle the methane, we can reduce emissions by about 50 percent by switching, for example, from coal to gas. And then the third, I think very important point, is that natural gas is also much more amenable to flexible generation, meaning, you don't have to turn it on and leave it on all the time.

So, that's sort of what I think about natural gas.

So, what can we do? So, right now, I think we have a huge opportunity to work on replacing base load, old, coal-fired power plants, which have high emissions, with natural gas. We'll reduce our C02 emissions, we'll also reduce the other pollutants --

MR. TANEJA: And you'd replace all of it?

MS. BENSON: I think that a practical number

might be on the order of something like 50 percent over a several decade period, looking out to 2035. I'd be interested to hear a perspective on that.

So, that's what we can do right now. Second, in the near future -- I'm actually a really big fan of wind energy, solar energy, wind we saw in the chart early today that it's competitive in terms of price, solar is coming down really rapidly, somewhere within the next decade it's going to be really comparable to other sources. So, we have the -- and we have vast resources of wind and solar.

The big problem, which we heard about, is that they are variable, they're intermittent, and they're only, you know, somewhat predictable. So, there's a huge opportunity to think about natural gas -- flexible generation with natural gas, the synergy with renewables to promote the increased deployment of renewables if we use that natural gas in the right way.

So, one is simple, variable generation. We can try to make that more efficient. The second thing

we can do is we can develop technologies that specifically deal with this synergy, so, for example, there are hybrid plants now that combine solar thermal electricity production with natural gas generation. It allows more efficient use of that gas. And, number two, we're moving towards 24/7 dispatchable hybrid energy systems. So, those are things we can do in the near future.

And then looking to the long-term, I think that if natural gas prices stay, you know, not $2 but if they're less than about $8/million BTU, then natural gas with CCS, Carbon Capture and Storage, is the lowest cost way to getting to ultra low emission electricity generation with fossil fuel.

There's work we've got to do, we've got to lower the cost of capture, we've got to improve confidence in storage, but that's possible.

And second, that will produce a source of C02 that can be used for enhanced oil recovery to further domestic production.

MR. TANEJA: Jim, how is natural gas

impacting your business today? And do you think you could run a big part of your portfolio on natural gas going forward?

MR. ROGERS: I would start by saying, today, we're dispatching -- we run our hydro first, then our nuclear, and then we're dispatching natural gas, before all our coal plants, even our most efficient coal plants. And so we've done the math, and gas prices have to get above $4.25 an mm BTU before we start dispatching our most efficient coal plant. We will always dispatch natural gas first.

Now, the problem for us, is we have huge inventories of coal and we're negotiating blend and extending contracts with our suppliers. I mean, that's a huge problem that we face. But our company said, we need to start the modernization early, so we built 2,700 megawatts, much gas, and we retired 3,700 megawatts of old, high emitting coal plants that were built 50 years ago.

And the bottom line is, is that those combined cycle gas plants are running all the time

just like base load units, and that is a change in thinking. We never thought you could run combined cycle like base load, and what we're finding is we can, and I think that's an important point.

But let me kind of raise a flag, and the flag really comes from being around for a long time. When I used to be a consumer advocate in the '70s, I sat in rooms where we allocated the use of natural gas between residents and industrial use. Then I was in Washington in '78 where we passed the law that said gas is a premium fuel, we're running out of natural gas in the United States. It is against the law to burn gas to generate electricity. Of course, that was repealed in '85.

And so I would just say this, my experience in all these years of natural gas is this, I'm going to pick up on Ben Franklin, he said, "There's only two things that are certain in life, that's death and taxes." I would add to that the volatility of natural gas prices.

(Laughter)

Now, the point -- the challenge that we have is because gas is so cheap, and yes, it's cleaner than coal, no question, our biggest challenge is the pressure we're going to get from regulatory commissions to build all gas all the time, and the strength, today, of the electric system in America is the fact that we have a portfolio of ways to generate electricity.

And my number one fear is that we'll be forced to build gas all the time, that will push out wind, that will push out solar, and by the way, my judgment on solar is, solar will trump wind everyday because of the distributed nature of it, and the cost, you know, it used to be $1 a watt, we're looking at 60 cents a watt today.

So, we are really moving forward in efficiency there.

The final point is, is that natural gas is critical, it's an important fuel, I'm glad we can use it, and we should use it, but we have to resist the temptation, as we retire and replace the existing

generation, to build nothing but natural gas. That would be a mistake.

MR. TANEJA: Vinod, do you want to comment on that and how -- the supply side of the renewable and efficiency companies progress from here?

MR. KHOSLA: Yeah. So, my overall comment is, I completely agree with what Ken said earlier and with what Jim's saying, we can't predict prices. So, I fundamentally oppose things that, say, in 2035, if such and such, gas is below $8. Four years ago, gas was above $14 and we were talking about exactly the opposite thing.

So, I also don't believe technologies take a long time to develop, so I'll defer with Sally. You know, we can always story tell around wind was invented in 1800. Nobody started working on wind and solar seriously until about five years ago. Okay. The other thing I would say is when GE, DuPont, Exxon start to work together, they'll do less in ten years than one startup with five people can do in two years. Just fundamentally true.

You didn't see innovation in retail from Wal-Mart, you saw it from Amazon. You didn't see innovation in pharma from Pfizer, you saw it from Genentech. You didn't see innovation from Shell Solar and Arco Solar, all these guys who got into solar, you saw it in First Solar. Media didn't change because of NBC and ABC, it changed because of Google and Facebook.

So, every major area, innovation happens at the fringes and moves. At some point it reaches economic viability and then explodes exponentially and the companies can jump in front of the parade, as they often do, which is great. Some areas need partnerships, most areas, by and large, don't need partnerships.

Having said that, I can tell you today that because of natural gas prices and this parity chart that you look at that Ken was talking about, it's going to disappear in five years, almost certainly. Why? Because I already know people who are developing natural gas to jet fuel, natural gas to ethanol,

natural gas to butanol technologies. These things will get levelized very, very quickly -- very quickly means five years, because it takes two or three years to develop a technology, it takes three years to build a plant, five, six years, assuming there's no financial crisis that shuts all R&D off, that's the nature of innovation in energy.

So, the fundamental key to understanding energy is to say, you optimize for flexibility, you don't optimize for one scenario. And anything that goes beyond predicting five years out is complete baloney. There's half a dozen major technology races going on, in my view, between solar and natural gas, hybridized versus battery storage versus compressed air storage. There's efficiency technologies that will reduce electricity consumption by 75 percent in a number of major areas.

Which of these races wins? It's hard to predict, and it changes the rules, and then we make up a new set of rules and pretend like it's going to be true for the next 30 years.

So, my view is, be agile, be really flexible, invent technologies, and almost all our problems seem completely solvable. I don't even know if distributed generation isn't going to be more efficient than large combined cycle 60 percent efficiency plants. I know people building internal combustion engines that have greater than 50 percent efficiency. Five years later they'll get to 60. Then it's way more efficient than a large combined cycle plant that GE is planning for 2020.

So, that kind of surprise will happen all the time.

MR. TANEJA: Okay.

MR. ROGERS: Can I be provocative just for one moment?

MR. TANEJA: Please.

MR. ROGERS: I mean, I just can't let you get away with that.

(Laughter)

I mean, I agree virtually with most of what you said, but here's the reality. Our industry is the

most capital-intensive industry in the United States. We build power plants with a time horizon of 40 years. And if we're going to have to retire plants and build new plants, we just can't sit there and say, can't move, don't know what's coming tomorrow. We have to put down $2 billion and build a plant that's going to last 40 years.

So, one of the challenges that we have is that we don't have the ability to delay for long periods of time. We've got to put money on the table, we've got to make investments, and they're 40-year investments, and it's locked down.

MR. KHOSLA: It is, but there's a simple way out of a 40-year investment, that's a bankruptcy.

(Laughter)

MR. ROGERS: Hey, listen, I just created a big company. I just don't want to hear that.

(Laughter)

MR. KHOSLA: Here's the reality. If Jim makes a 40-year investment, which I agree with you, you have to make these decisions, you have to keep

making measured bets, you sort of say, okay, natural gas price is going to be at a certain level and power generation retail pricing will be 12 cents. If I do a different technology that produces power at 12 cents and I go directly to consumers in a distributed way, you're going to have excess capacity.

Now, lots of things can happen, you don't have enough cash flow, you can go bankrupt, you can find alternative uses, some industries that have moved offshore might move onshore to eat up that capacity. This is a dynamic system and we have to realize, we have to place bets. The whole notion of being able to predict 40 years out is completely out of the window and predictability cycles are growing shorter and shorter and shorter.

Let me give you the statistics. Professor Tetlock at UC Berkeley, well captured in a book called *Future Babble*, did a study of 28,000 large forecasts, 80,000 small forecasts. The average accuracy of these forecasts was about the same as dart throwing monkeys. That's statistically rigorous data, right.

So, any time anybody says, in 2020, shut your ears and ignore it.

MS. BENSON: Can I respond just a little bit to Vinod?

MR. TANEJA: Please.

(Laughter)

MS. BENSON: So --

MR. TANEJA: You guys are making my job easy.

MS. BENSON: So, I just want to speak to Vinod's point that, you know, we're not trying to displace the innovation industry, the startup. As a matter of fact, we have three startups that are following through on energy developed technology, and even specifically that high efficiency combustion project you talked about, that was something we developed. So, we do think that's a very important part of the innovation cycle and we're not proposing to supplant that incredibly critical role that that group plays.

MR. HERSH: And I'd like to also make sure

everybody appreciates that -- and the wind industry has a perfect example. It wasn't three guys, you know, in a startup, it was three guys and Washington and if Washington wasn't there, those three guys would have found something else to do.

The Wind Production Tax Credit, when that expired, the entire wind industry shut down, okay, shut down, so even with the installed capacity that they have, it was apparent that from a business perspective, the wind movement of the last ten years was basically a transfer of wealth from the U.S. taxpayer and the utility rate payers to the wind developers, because as soon as that stopped, there was no industry.

Do I want renewables? Should we be more gentle on the planet? Absolutely. But I think we need to appreciate the whole ecosystem that Jim talked about. These are mammoth -- ERCOT in Texas is a mammoth installation, and when it's running 2 percent wind, that's okay. When it's 18 percent wind and the wind doesn't blow, the amount of backup power, if you

were to amortize that, that was not in any wind developer's math, and it wasn't in any taxpayer's math, if you were to put that into the equation, it was wildly expensive and the utilities wished they'd never heard of wind on some days.

So, I think it's just important to understand and differentiate, what problem are you trying to solve? If you're trying to solve the global climate problem, then we have to do something about burning coal, period. Okay? That's about it. If we took half the cars off the road, it would lower global emissions about 3 percent, not a big impact.

So, if you think about trying to create nice businesses to fit into a trillion dollar a year industry, then that's perfectly legitimate as an investment tool, but I think when we mix them is where we get into these issues.

MR. TANEJA: Let me go down a bit further on that particular topic. So, I think the seminal question for us out of this conversation is, to what everyone has been starting to address, which is,

natural gas has got an important role, but it needs to be a portfolio and it can't be an overarching bet on natural gas.

Now, the question is, to your point, what is the role of government in making sure we're actually marching down towards a portfolio? And today if you poll the people in this room and you say, what's the role of the government around helping in this sector, you would probably -- everybody would agree they should invest more in R&D and everybody would say they should not pick winners and losers, and there will be lots of controversy around a lot of things that haven't worked -- loan guaranties and the way the Recovery Act money was spent, and so on. It's all irrelevant.

I think the question to me is, is there one price signal that can be created? And the specific question I have for all of you before we open up to the audience is, if you were to pick between a carbon tax and an enforceable RPS that states have to go figure out a way to go implement and march down that

trajectory in the context of resources that are best for them as they develop and hit those thresholds for the RPS, what -- is there one of the two that you think could potentially work?

MR. HERSH: I think that, to your point, the only role the government could have would be to help price the externality. If the government were to price the externality sufficiently and accurately, not just carbon, I think water is probably the most mispriced commodity that we live with today and that if you priced water correctly, all the -- in the prior panel we talked about bonding requirements, et cetera, but a frack job that uses four million gallons of water, if water were priced correctly, there would be incredible innovation, and there is incredible innovation, around the use of water.

So, thinking about externalities, that's a good role of the government. Obviously, you know, you threw out the comment we could all argue we shouldn't pick winners or losers. I don't necessarily agree with that. I think there's a lot of people,

especially in this state, who think, no, we ought to pick winners and losers because some are just fundamentally better.

So, you know, I think that the government's role should be about externalities and let the market decide simply because if you have to subsidize the creation of the energy, you will bankrupt every single government on this planet. It is an $8 trillion global industry. You've got to let the market make it.

MS. BENSON: I personally favor a carbon tax and a carbon tax with some kind of predictability in terms of the pace of increase over time that will create certainty so people will invest in R&D and people will invest in infrastructure, and I think those are the two crucial things we need to do.

(Laughter)

MR. TANEJA: Off the record.

MR. ROGERS: Let me tell you, one of the things I've learned in life, nothing's off the record.

I would say this, the -- we need a price on

carbon, absolutely, we need a price on carbon and there's no question about that. I'm reluctant on a carbon tax for a couple reasons. I'm reluctant for one reason is how will the money be used, and when I talk to people in Washington, they think it's going to solve the healthcare problem. That's what one senator told me. Another senator told me, if we had a carbon tax and brought all this money in, it would help our defense, we wouldn't have to cut defense spending. And I'm saying, I thought we had this great ecological crisis that we have to deal with called climate change. Why don't we use the money to solve the problem?

So, first, I don't trust the government with a carbon tax to use the money to solve the problem. Secondly, there is an inherent unfairness to a carbon tax, and that's this. There are 25 states in this country where more than 50 percent of the electricity comes from coal. Why is there so much coal in those states? Let's go back to 1978 when 18 percent of the electricity in this country was coming from oil and we

were told by the government, wean yourself from oil, go build coal, go build nuclear, because that's the future. And we did that.

And so now what you've got -- we carried out national policy from the '70s and people are going to come back today and penalize people who carried out that national policy in the '70s by putting a tax, a disproportionate tax, on those who built coal plants. And that's why I support cap and trade because it allows you to put a cap on emissions and bring it down, it allows for a price, it allows the government to play the right role, set the target on emissions and the decline, and lets the market and the private participants come up with clever ways to solve the problem as the emissions cap declines.

To me, that is the right way, and the fact that the Republicans have demonized cap and trade, I think, is a travesty because they've forgotten their own history. It was really the first George Bush, along with a Democratic Congress, that passed cap and trade, and at that time, with respect to SO2, it was

believed, and Republicans said this, now we've moved away from command and control and we've now used market forces to solve environmental problems.

Let's get on message, because that is the right answer in terms of solving the environmental problems we have in this country.

(Applause)

MR. KHOSLA: Look, it's hard to disagree with some of the things that are being said. You know, pricing externalities is good economics. Jim described the complexity of carbon, you take it to the international level and you order an order of magnitude more complexity to the kinds of issues, the government told us to build coal and now we get penalized for it. At the international level it's an order of magnitude more complex.

As a pragmentalist, and I hope I'm wrong, and I often am wrong, I thrive on being wrong only most of the time, not always, and make a success out of the few times I'm right. You know, it's great, really through a financial business and the way we run

our business, you only lose one time your money, so you can be wrong eight out of ten times and make a lot of money.

But to your question, I sort of practically look at what's likely to happen in the next four, five years, don't worry about these issues. I'd like to, I hope I'm wrong, but I'm assuming that we won't be solving the healthcare problem or the environmental problem with a carbon tax.

I don't think that's necessarily a bad thing because it's forcing technologies to dole up new technologies that I claim will not try to defy the laws of economic gravity. Any time you have subsidies, you start attempting technologies that aren't good enough to compete unsubsidized.

I'm a fundamental believer that we do have the capability to dole up technologies that can be market competitive and incidentally have a green benefit or a carbon reduction benefit. I'm completely convinced it's possible. A carbon price, if it happens, will accelerate these. If it doesn't happen,

it won't stop them and we only invest in things -- I think out of the last 50 things we invested in, maybe one depends on the price of carbon and 49 don't, over the last five years.

So, that's the approach we take, that's sort of the pragmatic approach, and in some sense putting more of a stretch (inaudible) economic and build a business without the subsidy, it actually helps us stretch further, take larger technical risks, and have more disruptive economic breakthroughs. And those two generally go together.

MR. ROGERS: Let me just make a quick point. Job one for me is to provide affordable, reliable, clean electricity 24/7, 265 days a year. I really have to balance affordability objectives, and we just had a rate increase that allowed me to shut down all these plants because I built new plants that were more efficient, and reliability, as well as clean.

So, I can't look through any one lens. I have to balance all of those, and that's just the real world of where I am. And I think the other important

point is, is that I know there will be some price on carbon at some point in the next 40 years, and remember that blank sheet of paper that I'm working on to build a new system, so I factor in a carbon price on every decision I make about what I build with the assumption that there is a price on carbon, and that's the only prudent way for me to make these longer-term investments.

MR. HERSH: Can I get one more plug for the real world and to follow what Jim said? The node -- because I love Stanford. When I went here I loved it, I still love it, there's this sense of, why can't the world understand all the great stuff that's coming out of California and what we're doing. It's not just losing one time your money and why incumbents and why the industry has to do what it does.

Macondo was a $200 million exploration project and it turned into a $20 billion liability, okay. There were 2,400 barrels spilled offshore Brazil and 11 people got put in jail, okay. There is personal liability. The executives in this industry

are sitting on an enormous global set of enterprises and it's not -- it's not always just a simple equation. And it's a big industry and it's a big complicated industry, and I wish it had simple answers.

MR. TANEJA: Great. I'd love to open it up to the audience.

SPEAKER: So, I'm curious to hear a little bit more about this idea of like the five-person startups in energy technology, because I've always kind of been under the impression that it's not how energy innovation works because it's so capital-intensive. So, like, for the Internet startups you can have people, like, coding in their living room, but you can't, like, fit a wind turbine in your garage.

So, I'm sort of curious to hear more of, like, how these little startups overcome that problem and, like, maybe some examples of their success.

MR. KHOSLA: So, you know, as you might guess, energy startups is a complex set of things.

But so is startups in general. You mentioned Internet startups, but that's not the bulk of the startups. A semiconductor startup takes $100 million. A computer company or a storage company takes $100 million to startup. Enterprise software takes $100 million to startup. Biotech startups take $500 million to a billion.

So, when you look across the range of startups, I'd say 80 percent of energy startups fit right into what venture capital has done, which means some number between $30 million and $100 million in capital raised over five years -- 80 percent of energy startups. The other 20 percent, some are -- some you find creative ways to get funded. Others you just don't do because the environment isn't right or you can't wait for the right cycle of hype or pessimism or optimism in energy or look at somebody's strategic interests.

You know, Chesapeake Energy, because of the price of national gas, is now putting a couple hundred million into a couple of projects to convert natural

gas into fuels. You take advantage of that opportunity.

In other cases, we have companies that have done very, very interesting investments in China. There was just a press release around a billion dollar project financing investment for one of our companies with a Chinese coal generation partner, because they're looking for alternatives to traditional uses of coal.

So, you have to be agile, you change your strategy based on the market environment, but it is false to say that most startups take too much capital to be venture. A few do, and for many of those, there are other strategies around it. You can do very small-scale specialty chemical plants instead of fuels and then switch it over to energy when you have enough credibility to finance a fuels project instead of a specialty chemicals project, which works at a $50 million scale, which falls into what venture capital does all the time.

MR. TANEJA: Next question.

SPEAKER: I want to go back to a couple things you said very early in your talk, which I enjoyed very much, your remarks. You talked a bit about getting in front of the parade and you also mentioned a new business model for utilities, and I wanted to put those together. I'm now looking at the potential in my home -- I live here in California -- to achieve deep energy retrofits in my home to where I'm using a fraction of the energy I used ten years ago.

On top of that, I can put solar on my roof or take advantage of green energy purchases through my utility, but here's my point. When you put those together, honestly, no offense intended, my need for traditional utility is greatly reduced. The transaction between me and the utility is much more a back and forth sale of commodities. I buy from you on the coldest day of the winter, I sell to you during the warm sunny days like we have today.

The current tariff structure of utilities is weakly, perhaps not at all, inclined to address that.

Could you paint for us a brief picture of the utility of the future and how Duke Power is addressing that conundrum?

MR. ROGERS: I think you've made a very good point, and what you've described is the future that I see. And so since I'm a capital intensity business and I make money by deploying capital -- to give you an example, let's take solar. In North Carolina, we got permission from the state commission to allow us to put solar on the rooftop to our customers. And we've deployed it. They only limited it to 10 megawatts, or 50 million, but with solar panels that was really a $42 million investment at the end of the day, but we -- people got in line to let us put solar on their rooftop. And what we did is we paid them a fee, like it was a power plant site, and we effectively invested in it, we installed it, we operate it for them, and at the end of the day, we roll it into our rates in the same way we roll it into our rates when we provide a universal access by building lines that didn't make economic sense out to

subdivisions far from the load center.

So, I'm trying to change the regulatory model so I can invest and then subsidize solar through my low-cost nuclear and coal in the Carolinas, as a for instance.

The other thing that we're doing, many of these pilots that we're doing are on the other side of the meter. I believe that our business will go from being a kilowatt/hour seller of electricity, but to more of an optimizer of the grid. The ability to understand the algorithms of use within a home, deploy the devices -- and I can give you examples of how that works within a home -- understanding that, and then being able to optimize it in a neighborhood, optimized between different customer classes and optimize it with a grid.

So, the model is not one of selling -- yeah, we'll sell kilowatt hours, of course, but we'll optimize it, we'll invest in distributed generation such as solar on your roof, but we will invest in your home. We will work with Tendril, who we're working

with today in Ohio, basically deploying the Tendril technology so they have the capability to control and -- first, you know, electricity is so cheap in this country, the average rate is .10 cents, I know that's a little lower than California, but the important point is, people need to first be aware, and that's how Tendril does it with their portal, then secondly you then start to modify behaviors, and then subsequently technologies will come into play.

So, the model that I see is one of optimization, a model where we're deploying -- I mean, we have lower cost capital than all our customers, deploying that capital in the homes, in the businesses, and deploying it in distributed generation in the areas we serve.

Part of the reason we got in the wind and solar business, and this is picking up on your point on government subsidies, we make 400 basis points -- no, 600 basis points more on our renewable investments than we do in our base business just because by the time you get the tax subsidies and you project finance

it, you get terrific returns, much better than the returns in the regulated business.

But it's allowed us to learn the business so that we don't lose the investment opportunity.

MR. TANEJA: Last question.

SPEAKER: A question about possible additional -- there's a question about the role of government in all of this and possible additional role I'd like to get your perspective on, and that is, the government as an early adopter of energy technology, particularly the Department of Defense, where national security is tied closely to energy security and energy independence, both on facilities operating independently but also for operational energy in places like Afghanistan where the cost of energy skyrockets when you factor in the transportation costs and the cost of soldiers' health and well being as well.

MR. ROGERS: I would just quickly comment that I recently heard Secretary Panetta at a NATO event basically say the number one threat the U.S.

faces is cyber attack and how it could have a major impact if you shut down half of New York City, for instance, in terms of their access to electricity, and a cyber attack could well do that.

One of the reasons that they're moving toward islanding or creating micro-grids on defense facilities in the United States is to protect against cyber attack, so it's unhooked from the grid. I actually think that that is really going to lead us to rethink how our grid works so that we can adopt, kind of, more of a micro-grid approach, and that's where distributed generation comes into play, as well as energy efficiency technologies that allow you to do that.

So, I think that what they are doing is foreshadowing what will become what will happen in the U.S.

MS. BENSON: I would just further that. You know, I think, certainly the opportunity for distributed generation in those circumstances really makes a tremendous amount of sense and I think because

of the imperative to, you know, provide reliable, more safe energy in those environments, it also can provide the opportunity to drive innovation that, in the short term, would be too costly.

So, for example, there are drones that operate with fuel cells and they've actually really advanced the technology to store hydrogen in a more efficient way. So, that's an example, as that technology is built out, it could spill back over into the other sector.

Similarly, there would be a lot of interest in learning how to make chemical storage from electricity that you generate, for example, from distributed PV or wind and if that could be done, that would be not only a local benefit for those applications, but also spill back to the rest of the economy.

MR. TANEJA: Time's up for us. Please join me in thanking our panelists.

(Applause)

## MODERATED DISCUSSION: CHALLENGES AND OPPORTUNITIES FOR AMERICA'S ENERGY FUTURE:

**Moderator:**

ROGER C. ALTMAN
Founder and Chairman
Evercore Partners

**Panelists:**

HONORABLE JENNIFER GRANHOLM
Host, *The War Room*, Current TV
Distinguished Practitioner of Law and Public Policy, University of California, Berkeley
Former Michigan Governor

ADMIRAL GARY ROUGHEAD (RET.)
Annenberg Distinguished Visiting Fellow
Hoover Institution
Former Chief of Naval Operations

GEORGE P. SHULTZ
Thomas W. and Susan B. Ford Distinguished Fellow, Hoover Institution
Former U.S. Secretary of Labor, Treasury, and State

THOMAS F. STEYER
Senior Managing Member
Farallon Capital Management, L.L.C.

MR. ALTMAN: We want to remain on schedule to the maximum extent possible. And now we've come to what I hope will be the highlight of an otherwise already extraordinary day, which is our final discussion,

it's, in effect, about the future.

MR. SHULTZ: I would say right away, the highlight -- the quality so far has been so great that we just want to keep up to that quality.

MR. ALTMAN: I'm just doing it slightly more ambitious than that. Let me just begin, if I could, by saying there's been a lot of discussion today about energy policies which we would like to see and which would facilitate, among other things, a cleaner energy future.

There's been a lot of discussion about possibly putting a price on carbon, carbon taxes, cap and trade and the like. There's been discussion about further environmental protections relative to hydraulic fracturing. We've had discussions on accelerating the proportion of future energy supplies represented by renewables and topics like that.

But we do not seem, at this moment, to be living in an environment of public opinion or political climate such that such steps, or at least most of them, are likely over the medium term. So one

of the issues I'd like to see this panel get into is ways in which our political system, and for that matter, all of us as citizens, can move public opinion from its present divided state over all of these questions towards one which is more conducive to the types of policies which have been widely discussed already this morning. And I have a few questions that essentially surround that.

Now, we're blessed with an extraordinary panel here. There's no American, in my view, who is more experienced in public policy over such a long period of time nor a keener observer of it than the gentleman to my left, George Shultz.

And to my immediate right, Jennifer Granholm has been a very successful and certainly battle-tested governor, who saw her very important state, Michigan, through some of the most difficult and challenging times that any governor really in modern memory has faced and confronted, and now she is teaching and commenting about the lessons of that.

Gary Roughead, to my far right, was, until

quite recently, the Chief of Naval Operations for the United States. And he is, among other things, a 41-year veteran of the military. I'll get into this in a minute, but I think all of us realize the role that the United States military has played in advancing technology.

And finally, to my far left, Tom Steyer. My good friend Tom Steyer is a brilliant and very successful investor who has, together with George Shultz, become enormously active and influential and successful in California's policies on conservation and energy as a whole. I really don't think we could have a better group.

So let me just begin, if I could, with this question. And I'd like each of the four of you, please, to provide your own response to it, and it's this. Many, many times policy advances for the United States as a whole have originated at the state level. This has happened for good, maybe sometimes for bad, time and time again throughout American history, the states as proving grounds or laboratories for the

country. And in so many ways, California, in particular, has been at that forefront.

My question is, and I'd like to start with Secretary Shultz to my left and just go around, is whether California's experiences recently and those of certain other states have the potential to move the country towards a more coherent energy policy, and if you think that's possible, how you think that may evolve over the short to medium term.

MR. SHULTZ: Well, it's already had an impact. You remember when California raised our standards on car mileage, all you guys screamed and yelled and Washington went crazy, but now you've adopted them, so that happens. We have to be careful in California that we don't get too far out of step and then the people from Texas come and take our businesses away, but we're working on it. Right now California is in the process of putting into effect a cap and trade system. And Tom and I had something to do with keeping that there. But now we have to be careful we administer it well and we don't have it

lead to a lot of unnecessary problems. But if we can administer it well, keep it under control so it works, but doesn't do damage, then it'll be something to look at.

Just as I think when it comes -- people were talking about carbon tax, cap and trade, and so on at the last session. I think we should be looking very carefully not just at California, but, say, at British Columbia, where they have a carbon tax that's been there for almost five years, it's very successful. So we can look at how did they put it into effect, how do they make it revenue neutral.

I might say that the comments that Jim Rogers was making about how is the government going to spend the money, you avoid that question by making it revenue neutral and you avoid the problem of fiscal drag, and it's just about leveling the playing field. So I think there are all kinds of things we're trying to do here and I hope we can do them well and carefully so they do become a marker.

MR. ALTMAN: Tom.

MR. STEYER: Well, what we're talking about I think pretty generally as a government role is to price externalities, and there are a couple different ways that are obvious to do it. One is to try and price it explicitly and put in a tax, and that's really what people are talking about in a carbon tax. But the other way that is the traditional way for a state to do it, it is more of a meat cleaver approach, is performance standards. And basically that's what George is referring to, that California put in performance standards for clean air and clean water and just insisted these are the rules and that's how they priced the externality. And people complained about it and it's not perfect, but the fact of the matter is, it was adopted throughout the United States and it seems to have worked, and people seem to think that, from an economic basis, it's been very good.

And that's really the same thing that happened in terms of miles per gallon, that basically the state put in a high performance standard that ultimately got adopted. And that's really been the

traditional role of states that has been incredibly effective whether it is in building codes or lighting codes, that, in effect, they require behavior to take care of problems that aren't included in the private cost of energy or any other behavior. And if it's successful, and if it's a problem that is similar throughout the United States, then the federal government can look and see and adopt it.

And I think that that has happened. It is less political in certain parts of the United States to deal with these problems. It's more likely to have a solution or an attempted solution. And so I think that that role of states right now, when there, you know, seems to be such gridlock in D.C., is one that's as important as it's ever been.

MR. ALTMAN: Jennifer.

MS. GRANHOLM: I think it's a great question, because going through the states, I think, right now is the only way we're going to get energy policy in this country, and I just want to be realistic about what I see, unless you put people in

office in November who agree that we have to have a national clean energy policy. But at this moment, I don't see, from a realistic point of view, that happening. And so I think that through the states is the way to go.

But here's what I would propose, and I think it's a doable solution, because carbon tax is not going to be a doable solution, and cap and trade, unless it happens in pockets like it is in California, is not going to be doable across the country. But what could be doable is to model a clean energy policy after what I think was the most successful policy of the Obama Administration in terms of getting something done on the ground in the states, which was the Education Race to the Top.

And what the administration did was put a little bit of carrot on the table, about $5 billion, right. Bill Ritter and the states bent over backwards to raise their standards to have a piece of that, because governors right now are hungry and they will do what it takes to be able to access some dollars

that will create jobs. So if you have a clean energy race to the top, where you put a little bit of incentive money on the table, and say to the states, you compete for that, and then adopt standards that are innate and respect your resources and your geography, a state-based bottom-up strategy would allow, for example, the Southeast of the country to focus on biomass, and maybe the Northeast focuses on energy efficiency and biomass, and maybe the Sunbelt focuses on solar. But whatever it is, it respects both the geography and the job situation at the state level, but it requires the state legislatures to adopt an RPS, to adopt energy efficiency standards, to create demand side strategies, as well as supply side strategies, regional clean energy banks.

And the DOE could put money on the table to have the state -- the country divided into regions and allow these states to compete for it as regional entities who require them to work together since resources know no geopolitical lines. I think a strategy like that would get Republican and Democratic

governors on board.

When the Race to the Top for Education happened, you saw 46 states change their standards for education and do something they never had the political will or capital to do before. You could get this done if you respected the states.

MR. ALTMAN: Gary.

ADM. ROUGHEAD: I'm going to put a little bit of a bank shot on this one, because -- and you think of the military in terms of two entities: one, the part that goes off and deploys and operates in foreign countries, and yet there's an entire infrastructure, a base infrastructure, an industrial facility infrastructure that exists here in the United States, in the various states around the country.

What do you have in the military? Right now you have a military that is very energy focused. It has been the most consistent, most focused energy policy in the Department of Defense in the four decades that I've been around. So you have a very receptive department.

The other thing that you have in the military is a very disciplined group. And you also have an entity that is looking for new innovation. The last panel talked about how we want more distributed power systems, how we want to secure the grid because of cyber threats and even physical threats.

And so my point is that you now have an environment that for those states that have military installations, they are the perfect entity with which to try the new technology, with which to try new schemes on reducing energy costs, energy dependence, and enhancing energy security. So a little bit of a different take, but I really do believe that now is the time for the states and the Department of Defense to partner on energy issues so that we both win and really advance the ball.

MS. GRANHOLM: I love that.

MR. ALTMAN: Now, hold some further thoughts on that, because if you don't, you'll steal my next question.

ADM. ROUGHEAD: Okay.

MR. ALTMAN: George, I know you want to comment.

MR. SHULTZ: I just wanted to add, we think of decentralization and we think states, but don't forget individual businesses. And as Jim Rogers was talking, you can see an awful lot of innovation, and it be not in the others in the last panel, so the bottom left is not just what states do, but it's what individual companies do, and that spreads out through the marketplace, and that's very powerful.

MR. ALTMAN: Let me ask this follow-up and, Jennifer, maybe you want to comment on this, or anyone else on the panel would like to. A whole series of states adopted their own renewable standards. I don't know the precise number, but a lot of them. New York State did that, for example, and it was really widely done throughout the Northeast, but lots of other parts of the country, too. Somebody can correct me, but I believe Texas did that, also.

I was always somewhat skeptical of that

because I didn't see at least most states having the capacity to actually enforce those. So my question is, in general, are those standards -- is there progress being made toward those standards, are they actually being achieved? What's actually happening in that regard?

MS. GRANHOLM: They are absolutely being achieved. But you're right that not all states have them. And there's a lot of political machination in particularly the Southeast. Those states do not have renewable energy standards or renewable portfolio standards.

But as they are adopted, you have to make sure that the, you know, the utilities have to be in the game, right. They've got to be able to have something in it for them or it will not happen. And so, therefore, decoupling energy usage from the compensation that those energy companies get is just a really important aspect of enhancing both energy efficiency, as well as adoption of renewables.

But the bottom line is, yeah, it is

happening, it's just a patchwork. And if you want to have a national energy strategy, to have a patchwork is not effective. You've got to have a national floor at least that you want to have these states get over for renewable energy. And the push that you make on it and the way you can get it through the states is based upon jobs. Every single one of your governors -- I mean, John Kasich from Ohio, Republican, recently said that he believes that climate change is real, which for a Republican to say that honestly is sort of a news flash to begin with. But with all due respect, because I know that we have an exception on the panel here, but --

MR. SHULTZ: Well, there's a historical exception. Teddy Roosevelt was --

MS. GRANHOLM: Well, go for it.

MR. SHULTZ: The Montreal Protocol was Ronald Reagan.

MS. GRANHOLM: Yes.

MR. SHULTZ: You mentioned the cap and trade of G.W. Bush.

MS. GRANHOLM: So, yes. (Laughter and applause)

MR. SCHULTZ: I even brought Tom Steyer around. (Laughter)

MS. GRANHOLM: But you've got to have today's Republicans jump on board. And the fact that Kasich is willing to say that climate change is real is simply because Ohio is the number one state in the country right now for manufacturing wind turbine. And as a result of that, he's employing people, and he doesn't want to see the production tax credit end because he's going to lose those jobs. So, yes, it's happening. It's not happening enough, which is why I think you need a national push to make these states adopt.

MR. STEYER: Roger, can I just take a second? I mean, I think there are 37 states that have RPS standards, and I think of those, 29 of them have mandates, and most of those are full in the sense that they have reached the level at which they're required to reach. In some places, advocates are trying to

change the RPS standards and raise them. And I think, you know, this is a little bit of a meat cleaver approach in the sense that you're trying to get to a goal, and you simply put the goal there and insist on it and let everybody fight, let the market work out the best way to have it happen. But this, you know, in terms of actually getting things done and seeing what happens, this kind of rule is what changes behavior on Monday morning.

And so as opposed to waiting for the perfect regulation, this is a way to actually have things get done, actually have demand for this commodity so that you can push down the price code.

MR. ALTMAN: Let me turn to, if I could, a related, but somewhat separate question, which, Gary, I'd like to direct to you, and it's expanding on what you said earlier, and I think it's in the spirit of the first question, namely, sectors leading the country, in effect, with change coming to Washington rather than from Washington.

Time and time again, over the last 50 to 75

years, the U.S. military has been the driver of technological breakthroughs. We saw that in computing itself, we saw that in the development of the Internet. Arguably, we're seeing it right now in terms of robotics and drone technology. And my question is, can our defense sector, because it has so much muscle, be a leader in terms of energy efficiency and, in effect, conservation and cheaper fuel and the like? So tell us a bit about what is actually going on now in this regard, because we hear a lot of stuff about it. And what do you think the potential is?

ADM. ROUGHEAD: I think the potential is great. And to your point, you know, we do take pride, and even though some folks may say the military is a rather bureaucratic organization, but when we move, we do move quickly, just in the area of power. We uncorked the nuclear genie in the mid-'40s, and in the mid '50s, we were sailing a nuclear submarine under the Arctic icepack, and that's pretty hard stuff, that's really varsity stuff, and that has continued on.

I think that the wars that we have been involved in for the past 10 years have caused us to rethink energy, particularly when you're fighting insurgencies. When the threat is 360 degrees around you, you have to be agile, you have to be nimble, you have to be as self-sufficient as you possible can. That's the drive toward distributed power, that's the drive toward energy efficiency. And so that has been a huge forcing function. And as those wars wind down, we can't lose that sense of urgency. We have to be able to sustain that, and we have to be able to continue to learn the lessons as we go forward.

I would say, though, that there's one thing that must happen within the Department of Defense in order to accelerate the initiatives in energy, and that is that our procurement system is biased toward today. In other words, if I want to buy something, the entire debate occurs about is A cheaper than B, and delivering the same results. We have to begin to have a longer view of total ownership costs over time, which are the energy costs, people costs, and the

maintenance costs that go with maintaining these high-end systems.

Until that is injected into the procurement decision, I'm afraid that we are not going to be pressing the energy efficiency pedal as much as we have to. But I really do believe that, for the reasons I mentioned in my first answer, that we have some real motivation to advance the distribution of power, the security of that distribution, and in minimizing the amount of energy it takes to do the business of the military.

Just in Afghanistan alone, with a couple of solar blankets, we have taken 70 pounds off the back of a soldier, because they're no longer carrying 70 pounds of batteries. That's a real motivator for a young 19- or 20-year-old, and we have to take advantage of that whenever we can. So I think there are plenty of opportunities. I do think we have to make sure that the procurement system changes, but the opportunities are there, and we have to stay on.

MR. ALTMAN: Let me follow up by asking

this. Historically, in its own way, the Defense Department has invested in technology development. And when you talk about things like the solar blanket example you just mentioned, to what extent is the Defense Department investing in pushing technology now, or is it just a consumer of what's being --

ADM. ROUGHEAD: I think one of the -- yeah, I would say that, you know, clearly through DARPA, we are getting some innovation out of DARPA, but it's really in how you apply some of the technology. And I've always maintained that give me the best engineer, design a system, and let me give it to a 19-year-old sailor, and a week later it's going to be better than the engineer ever thought it was going to be possible to be. That's how innovative our people are. So I think that that really enters into it. How you use these things is really, I think, a great contribution that the military can make.

MR. ALTMAN: George, would you like to comment on that?

MR. SHULTZ: I'd like to add I'm a Marine,

so naturally I'm biased and I look at what the Marines are doing. And just to build on what Gary was saying, I understand in Afghanistan the Marines have a device that you can hold, it's about this size, a little heavier, but you can hold it in your hand like that, and you open it up and flip it out, and what it is is 12 solar panels. Installation cost, zero. And you then use that to charge up all your stuff so you don't have to carry that heavy backpack.

Well, I looked into this a little more. Where did they get that? And I find out there is a commercial -- a company that's making versions of that, and they come in all sorts of sizes. And people who have jobs in remote places or who like to go hiking in remote places and so on have the same kind of problem. And they're selling these things. So it's kind of an interesting spillover into the civilian economy, and, on a small scale, an illustration of what seems to be happening with the military quite a bit.

MS. GRANHOLM: Can I jump just really

quickly on this?

MR. ALTMAN: Please.

MS. GRANHOLM: This idea of partnering between military and states is so critical. Just one quick story about that. In Michigan, we have a base that is really doing a lot of research into the battery for the electrical vehicle, and, of course, that same technology being deployed commercially, that effort has helped for Michigan to create a cluster of battery companies, advanced battery and energy storage companies, and the military is interested in it for obviously their use in vehicles, but also for stationary and distributed, you know, saving of energy, especially if there are those smaller solar uses.

So the link between them can get these governors and businesses to team together to advance technology, not just in the research, but in the commercialization of it.

MR. STEYER: Roger, can I make a point, too?

MR. ALTMAN: Please, Tom.

MR. STEYER: Which is this, you know, I know the military, DARPA, has this history of great research and innovation which is well deserved, but the ARPA-E group within the Energy Department, which, no surprise, was really started by Secretary Chu -- if you get a chance to meet them, and I'm sure a bunch of these people sitting here and a bunch of you people sitting there have met them, are really terrific. And when you see the way they use the taxpayers' money and the results, it's actually very impressive and heartening to know that a really terrific group of people are doing something very smart with our money long term that otherwise wouldn't get done. And I know DARPA has that reputation, but ARPA-E should have that reputation.

MR. ALTMAN: George.

MR. SHULTZ: I'd like to say something just underlining a point that Tom just made. We have had in this country a rollercoaster ride looking for more energy efficiency and alternatives and so on. I was secretary of the Treasury in 1973, when the Arab oil

boycott came. I was aware that President Eisenhower had said if we imported more than 20 percent of the oil we use, we were asking for trouble in national security terms. And when the Arab boycott came, I said, you know, President Eisenhower had a point. But everybody went crazy and said, okay, we've got to find alternatives and so on, then the price of oil went down and everything stopped. We've been through that rollercoaster now three or four times.

This time, however, there is a greater mass of first-class science and engineering going on working up all aspects of the storage, solar and so on that's been referred to earlier. And this time, when the price of natural gas comes down, the price of oil comes down, plus what's happening which seems to be so -- I think we have to do a really good job in the political arena of seeing to it that the funding, that we have adequate and sustained funding for the energy R&D. Don't let up this time.

I'm not talking about the government funding commercial operations. I think they'd be well off to

stay away from that. But fund the energy R&D so that we don't lose this momentum that's now going on solar energy and wind and storage. Big-scale storage is a huge, important thing and so on. So that's a plea I have, and I think that's going to be one of the big political battles, to keep that process going.

(Applause)

MR. ALTMAN: That actually gets into my next question, but before saying it, I'm really pleased that you brought up your tenure as secretary of the Treasury because I knew coming into this event that there would be one great former secretary of the Treasury at this event, and I was trying to remember who that may be.

MR. SHULTZ: I like Rubinomics myself. That was a golden age.

MR. ALTMAN: Here's my question. It really plays on the rollercoaster point you made. There's a lot of -- a certain type of optimism out there now about what I'll call a revolution in energy production, in particularly gas and oil production in

the Western Hemisphere, and the degree to which it may cause what I'll call a geopolitical reset, and in particular an end to the supply instability centering around the Middle East and the extreme dependence which the United States in particular has had, which has caused so much of the geopolitical disorder of recent decades.

And I've seen forecasts, and there's been a fair amount written about this, Dan Yergin just wrote about it, for example, a few days ago in the *New York Times*, about how over the next 20 years the Western Hemisphere may become energy self-sufficient; that between rising gas production in the United States, we've all talked about that a great deal today, rising oil production in the United States, rising Canadian production, the extraordinary offshore sub-salt finds that have occurred in Brazil, and the possibility of opening up PEMEX in Mexico -- which Mr. Pena, the leading candidate for the presidency in the elections in three weeks, is favoring -- that look ahead 15 or 20 years of the Western Hemisphere will be completely

self-sufficient. It doesn't mean we'll never import another barrel of oil from the rest of the world, but the center of gravity of oil, global oil, will move back, arguably, to the Western Hemisphere, where 50 years ago it was. My question is, first, do you think that's likely? Second of all, would it really cause a big geopolitical reset? And should we be celebrating it or do we view it as a mixed lesson?

MR. SHULTZ: The people on the last panel were very knowledgeable about this and they all kept saying I don't want to try to predict anything, so I'll bow to them. Nevertheless, it does look to me as though these new technologies have opened up supplies of oil and gas that were certainly not thought to be there even a few years ago.

So I think it's quite possible that the geopolitical landscape changes. And it's not just sort of energy in a kind of direct sense, but it can change the power structure of the world. It can rearrange the position of countries. We will stop financing Iran's nuclear program, for example, and

things like that. So it can have a huge effect, so I'd like to see it proceed.

And one of the refrains, particularly I remember Dave's panel right at the beginning, is it's going to proceed if people do it carefully and be sure that it's done properly so it doesn't blow up in our faces. But from what I can see, that's quite possible, there's no reason why it can't be done right, and so I hope it will be and it will change things.

But as I say again, let's not close prospects, cause us to back away from the present strong work on the energy R&D. Particularly I go back to Gary's comments, the importance of distributed energy is really big time. Cyber attacks on the grid that Jim Rogers mentioned, you have to worry about that, and all sorts of ways. Energy produced near where you use it makes a big difference.

I'm always struck -- we had a fellow here recently, he was a Navy guy, and he said I'm a pilot. Every pilot knows you can go down. I've flown a lot

of missions in Afghanistan. If I go down, and he pulls a little thing out of his pocket, and he says, I turn this on and my friends know where I am. The only problem is, it only lasts 48 hours.

Then he pulls out another little device, little round solar panels. What's that for? My recharger. It's distributed energy and it has a lifesaving component there. But there are all sorts of examples of why it's so important to focus on distributed energy from a strictly national security standpoint. I know Gary wants to say something.

ADM. ROUGHEAD: I would also add that, you know, in the military, you prepare for the uncertain. I mean, that's what our lot in life is. And it's great to be able to predict what the markets will be like. But for the military, we have to be able to go off and operate in places where we may not be able to get a particular source of energy. And so that's why I think this most recent initiative that we've had, sustained initiative, really is giving us options on energy. And it is also focused on making us lighter,

more expeditionary. And so as we look at our energy future, you know, it's great that the markets may move in certain areas, but we want the flexibility, we want to be able to adapt to the environments that we're going to be in and be as self-sufficient and as efficient as we can.

MR. STEYER: Theoretically, if this Western energy self-sufficiency occurred, the security role of the United States in the Middle East would change a lot, or could change a lot. In fact, the centrality of the Middle East itself geopolitically could change a lot, and eventually that would have perhaps big consequences for the shape of our defense footprint.

ADM. ROUGHEAD: I think so, but I think the other point that I would make there is that it's our presence in those places that really makes a difference in the global security structure. So I think it -- do we want to remain forward, do we want to remain engaged and be the guarantor of that security, and, you know, we need to put that in the calculus, as well.

MR. ALTMAN: Okay. I'm going to ask one more question before we turn to the audience, and I'd like to ask about the relationship of energy policy and climate change in the following way. Let me reveal my own bias at the start. I am an optimist by nature, but I am not optimistic about the climate outlook. And it's no surprise, I wish it were otherwise, but it's no surprise to me that the global negotiations over climate change -- Copenhagen, Cancun and so forth -- have gone essentially nowhere, because expecting huge developing countries like China and India to undertake the reforms and the sacrifices which the advanced countries would like to see seems, to me, a very difficult expectation. And even more fundamentally expecting human beings to consume less as their capacity to consume grows also strikes me as a very difficult expectation.

Now, my question is, and I'd like all the panelists to speak to this, if you would, is there any realistic expectation that there will be a negotiating agreement which actually makes a dent in the climate

outlook or, alternatively, is the only solution actually going to come from technology, not negotiations? And, Tom, I might start with you.

MR. STEYER: How is the climate crisis going to get addressed? Well, clearly, we are not -- we are making progress in terms of -- when I think about 2011, a lot of people feel as if it wasn't a good year from the standpoint of environmentalism or energy progressiveness, but actually if you look at what happened in 2011, there was a lot of progress in the way of the mercury rule, the miles per gallon rule in D.C., a lot of good things happened. But I go back to Dave O'Reilly's presentation at the very beginning, which is, we're driving down energy usage in terms of per GDP, we're much more efficient than we were in terms of heating and lighting buildings, we're much more efficient in terms of driving cars, but overall usage is going up, and around the world it's going up quite a bit.

And so even though we're doing a lot of things that are very good, it's not enough to overcome

the basic fact that 7 billion people are using more and more energy. We are making progress, but it's not as much, it's not enough to overcome that basic fact.

So I look at this a little bit like, if you'll excuse the expression, because I wasn't around, World War II, in the sense that we're sitting over here in 1938, and you have a sense that there's something big that we are going to be facing in a very real way, but the country's not ready for it, and so we do a whole bunch of things to try and get ready for it.

We do lend-lease, you know, we try and get bases prepared, we do all these things, but the country is not ready to actually step up and face what is a crisis which isn't apparent to them on a daily basis. And so when you ask is this going to be negotiated without, you know, is technology going to save us, is this going to happen without any pain, my guess, honest to goodness, is no, that we have to work as hard as we can to be prepared for when something happens to flip the switch and we realize, no, it's

here, we now have to deal with it. But I believe that there will be some event that changes the way we think about this, and that actually the way we've described things in this conference, and I've been incredibly impressed with the people who have been here, I think there's a good chance that extrapolating all those lines, how I've been thinking about it in a historical context, will be different because things will really change, and our framework for thinking about this will be forced to change.

MR. ALTMAN: Jennifer.

MS. GRANHOLM: It's a fascinating question about whether it's going to be technology or negotiations. And, of course, if there's negotiations, it means that that -- the product of that, whatever the treaty is, has to be approved here, because I just go back to politics on it, and unless we've got people in Congress who are willing to ratify such a thing, then I tend to believe that technology is going to take us faster.

However, it is not enough. And given the

pace of change, it will not be enough unless the United States decides to lead. And I do think that one way to be able to get the political consensus or the argument that might have some traction. And if you look at recent public opinion polls regarding should we have a national clean energy policy, the vast majority of the public are there, it's just the people that they've put in office are not. And why is that? It's because often those people are supported by interests who don't see that it works for them, whether they're, you know, they're companies or oil interest, they don't see it.

And so truly, truly, I feel like small democracy has to work. Over 50 percent of Tea Party members think that we should have a national energy policy. I mean, what is the disconnect here except for the influence of some very powerful individuals who have persuaded those that have been elected?

So I think that we can get the right people in office to be able to get the national support that you need, but I think the argument has to be about

whether the United States is going to fail at this issue.

In fact, I think that when you look at the amount of money that has been invested in clean energy globally since 2004, that there's been a 600 percent increase in private sector investment in clean energy globally, but the United States is -- I mean, the United States is doing all right, but if we had policy, we'd really get those jobs. And all those jobs are being created somewhere. And the question for us as a country is, are we going to get some of that? And the only way to get that is through policy. And if you tell people on all ends of the spectrum that we are losing out not just in national defense, but in the jobs war, the war for jobs globally, that we're losing out because Washington is failing to act, to me, that allows us to have a competitiveness argument that the United States cannot continue to be weak in this area of job creation and clean energy.

So I do think that technology is going to be the biggest catalyst. It might get us there sooner,

but it's just not going to be enough unless we have a global solution. And if we don't act, other countries are going to eat us for lunch. And, you know, we can either choose to be at the table or on the table, and me, I prefer to dine. (Applause)

MR. ALTMAN: Gary, do you want to comment?

ADM. ROUGHEAD: Well, I've never met a disappointed pessimist, so you can -- you know, I'll tell you where I am. I really do think that the technological path is probably the one that I would have the most optimism about. But I really do believe that as we go down the climate change path, and recognizing that this is an energy conference, that there will be a series of crisis that will do more to awaken the global population, and it's all about this water.

Because we're here talking about alternative forms of energy and how we can balance those off. I don't know what you have as an alternate to water. And we are marching down that path I think more quickly than many people realize, and that will be the

wake-up call.

MR. SHULTZ: Let me make a few comments of a variety of sorts. First of all, this guy is something of a genius. I had the privilege of working with him on a political campaign, and we emphasized three things: we emphasized national security, we emphasized economics, and we emphasized environment. I say “environment” rather than “climate change,” because the environment is more than just the climate. And there’s something immediate that gets people’s attention, that’s the impact on their health of what they breathe. And Tom produced an ad that we had that had a woman who looked like your mother. She was the head of the American Lung Association. She said be careful what you’re breathing, and it made a gigantic impact.

And the climate business is something you have to do today for something tomorrow. Your immediate health and what you breathe is right there with you. So I think as these issues are presented, that’s something to think about.

On the negotiating side, I must say I think these negotiations with jillions of countries on a global basis will never work about anything. We did the Montreal Protocol, and the way that was done was we went around to key countries and pointed out to them -- I might say the U.S. took the lead diplomatically, scientifically -- but we went around and said, look, here's this thing that's happening to the ozone layer. Most scientists think it's real, some question. They all agree that if it happens, it's a catastrophe and not reversible, so we better take out an insurance policy. And once we got key countries involved, then others signed on and we had a global solution, had to have a global solution. But it started with the Corps.

Then we were very fortunate, and here's the technology side, the DuPont company came up with an invention that was relatively simple and straightforward and not expensive that did the job. So it came at just the right time, and it was a good interaction between diplomacy and the coming of this

new technology.

They might say you talked about getting the Senate to confirm things. When they brought the Kyoto Treaty back it was insane, because the Senate had already voted 95 to nothing, don't bring that treaty back. So the thing I was taught, and worked and we got a lot of treaties ratified, including Montreal Protocol, no problem, the key as the U.S. negotiators remember this, if you want me with you on the landing, include me in the takeoff. You've got to include the senators on what you're doing, let them know, consult them, listen to them, they often have good ideas. And by the time you bring something back, they're all well aware of it and they're pretty much on board, then you can get it ratified.

So there's a process here that you have to respect, and all these senators, you know, they are big shots and you have to recognize that. You say yes, sir, Mr. Chairman, and that's the way it is.

MR. ALTMAN: Well, George, I always thought of you as a person of absolutely exquisite judgment

until I heard those comments about Tom. (Laughter)

Let's move to the audience. Let's have some questions here for a few minutes. Yes, sir, over here in the front.

SPEAKER: It's been a fascinating discussion. And through it all, two themes have been hiding in the background. I call one of those let's tilt the playing field and let the private sector figure out how we should get to where we want to go, and the other one is, let's tell them what to do. We've had examples, like the revenue-neutral carbon tax or what I would call your race to the bottom in emissions, where you just say reduce and get money, and we had Tom Steyer talk about the renewable portfolio standards.

Now, we had Sally Benson talk about carbon capture and storage for natural gas, a huge benefit if it worked. And under Tom's proposal, it's not allowed, it's not included in renewal portfolio standards. Is one or the other preferable or do we need a mix of both? And how do we judge what we

should be pushing?

MR. ALTMAN: Well, Tom, you're on the hot seat here.

MR. STEYER: Well, Burt, thank you very much for putting me on the hot seat. I think -- I've been in the private sector my whole life and I really believe that in terms of getting things done, if you have 300 million Americans working on it and personally engaged and incented to get something done, we're going to get the best possible answer. I mean it's just an extension of what Admiral Roughead was saying about the 19-year-old midshipman.

On the other hand, in terms of setting standards and determining where we have to go, I think that is the job of a government, particularly when you're talking about rules and externalities. And I certainly am not someone who believes that markets are perfect. And so that is the government's role, is to say where we want to go, to have a vision, to set the endpoint, and let the rest of the country figure out how to get there in the best way.

MR. ALTMAN: Next. Yes, sir.

SPEAKER: To the earlier comments about the states as laboratories and California, about implement a cap and trade system hopefully later this summer, the Northeast has already had a cap and trade system for several years, RGGI, the Regional Greenhouse Gas Initiative. And recently a report came out talking about how over the last three years, under RGGI, carbon emission, or greenhouse gas emissions rather, from the Northeastern states, the nine participating Northeastern states, have dropped by about a quarter while electricity use has been essentially flat. And the overall greenhouse gas emissions have been about a third below what the mandated cap brought them down to.

So clearly there's been some success in seeing cap and trade work at the state level in the Northeast. That said, when Mitt Romney was governor of Massachusetts, he pulled Massachusetts out of RGGI. It was Deval Patrick who came in and put Massachusetts back into RGGI. Chris Christie as the new governor of

New Jersey pulled New Jersey out of RGGI.

So given both the success -- and there's also been an economic success, by the way, with $1.6 billion of economic value creation for those states over the last three years, and 16,000 direct job creation. Given that economic success and the benefits of cap and trade, what does it take to get today's Republican political leadership, people like Mitt Romney and Chris Christie, to come around on this issue?

MS. GRANHOLM: George.

MR. SHULTZ: Well, I don't want to turn this into a partisan gathering, which it seems to me it's veering toward. One of the magics of this, to me -- and I was saying this to Roger and Bob Rubin earlier -- that, for me, the Hamilton Project represents sensible Democrats, and I think of myself as a sensible Republican. And I'm really closer to the sensible Democrats than I am to some of the extremists in my own party, and I suspect the same is true of you. So what we need to do is nourish some sort of a

center. And I know Chris Christie and Mitt Romney, and they're both hard-hitting, sensible, thoughtful people. So we'll just have to see how this rolls around. And Christie, as far as I can see, I grew up in New Jersey, so I kind of like the state, and thank God he's there, he's turned it around. He's making New Jersey into a good place. And we'll just have to see.

My observation, having served in the Eisenhower Administration -- for you younger people, he was a general that became President -- there's nothing like being in office to sober you up, and it really makes a difference. I know, as an example, early in his presidency, Ronald Reagan asked the Joint Chiefs of Staff to tell him what would happen if there were an all-out Soviet nuclear attack on us, and they came back with the answer: initial casualties around 150 million people and gross follow-on casualties because we have no infrastructure left. So somebody asked, would you retaliate? Yes. What would happen? The same thing. So he said what's so good about

keeping the peace through an ability to wipe each other out? And gradually that led to reductions in nuclear weapons. The Reykjavik meeting called for eliminating nuclear weapons. I might say we're getting -- I've been working on this probably, you know, a lot longer than others here -- Bill Perry, Sid Drell, Sam Nunn, Henry Kissinger -- and right now the number of nuclear weapons in the world are one-third of what they were at the time of Reykjavik.

So I say to you, okay, listen to what people are saying, but you get in office and it's a very sobering experience, because there's a reality there. And at least as I sense it, there's a reality coming out of some terms of what's happening to the temperature of the globe, and it's dawning on people.

I read that even Vladimir Putin, who seems to be in trouble in Russia right now, but anyway, I think a couple of years ago they had the hottest time on record in Moscow, by far, then he went to the Russian Arctic and he saw it was melting. And he came back and he said, even as Putin, he said, you know,

something is happening.

And there's a reality, you can't avoid it, and that reality gets very persuasive. And I think in the end, that's going to cause people to say we really have to get serious about this, the sooner the better. And if you're a little bit skeptical, at least buy the insurance policy strategy that motivated the Montreal Protocol. So I say we have these figures in front of us, energy is a big one, climate is a big one, and we need to work on them, try to get something done, and the key is never give up, work on it.

MR. ALTMAN: Well, on that really very profound and wise note, I want to thank this extraordinary group of panelists. I want to thank you, George, for those kind words about the Hamilton Project. It's been a great opportunity for the Hamilton Project to come here to California and to cooperate on this event with Stanford and to partner with Stanford on this and to work particularly closely with Tom and with George on doing this event.

I hope you have all enjoyed it and found it

rewarding. Thanks to all of the panelists and participants. (Applause)

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